2007

Baseline assessment of neotropical migrant landbird stopover habitat in the lower Chesapeake Bay region for conservation planning and protection

S. E. Mabey

B. J. Paxton
The Center for Conservation Biology, bjpaxt@wm.edu

B. D. Watts
The Center for Conservation Biology, bdwatt@wm.edu

F. M. Smith
The Center for Conservation Biology, fmsmit@wm.edu

Recommended Citation

Mabey, S. E., B. J. Paxton, B. D. Watts, F. M. Smith, D. Dawson, and B. R. Truitt. 2007. Baseline assessment of neotropical migrant landbird stopover habitat in the lower Chesapeake Bay region for conservation planning and protection. CCBTR-07-16. Center for Conservation Biology Technical Report Series. College of William and Mary, Williamsburg, VA. 63 pp.

BASELINE ASSESSMENT OF NEOTROPICAL MIGRANT LANDBIRD STOPOVER HABITAT IN THE LOWER CHESAPEAKE BAY REGION FOR CONSERVATION PLANNING AND PROTECTION

USGS Science Support Partnership Program
Cooperative Agreement 03ERAG0040

INTERIM REPORT
March 2007

SUBMITTED BY
The Nature Conservancy
Virginia Coast Reserve
P.O. Box 158
Nassawadox, VA 23413

PREPARED BY:
Sarah E. Mabey[1], Dept. of Zoology, North Carolina State University
Bart Paxton, Center for Conservation Biology, College of William and Mary
Bryan Watts, Center for Conservation Biology, College of William and Mary
Fletcher Smith, Center for Conservation Biology, College of William and Mary
Deanna Dawson, USGS Patuxent Wildlife Research Center
Barry Truitt, The Nature Conservancy

[1]Current Address: Dept. of Biology, Sweet Briar College

TABLE OF CONTENTS

INTRODUCTION

The conservation of highly mobile species like Neotropical migratory landbirds presents considerable challenges. Areas used during all phases of their life cycles must be protected, ideally with greater effort and more resources dedicated to protecting species when and where individuals and populations are most vulnerable. This requires detailed knowledge of the dynamic distribution of individuals, resources, competitors, predators, and exposure to natural and anthropogenic threats. Rarely do we have the ability to thoroughly define all of these critical parameters along both their spatial and temporal trajectories.

Researchers and conservation practitioners have made strides in identifying factors that limit Neotropical migratory landbird populations during the breeding and wintering seasons (Sherry and Holmes 2000) but far less progress has been made identifying limiting factors that operate during migration (Sillett and Holmes 2002; Mehlman et al. 2005). Given that most migratory landbirds spend one half to two-thirds of their lives migrating between breeding and wintering ranges, this knowledge gap represents a significant weakness in our ability to develop effective conservation strategies for maintaining viable populations of Neotropical migrant landbirds. This is especially obvious when large numbers of birds concentrate during migration, and holes in a protective safety net may translate into large-scale population losses for some species.

Many significant migratory stopover concentration sites for landbirds are well-known and well-described (e.g., Cape May, NJ, or High Island, TX). Most of these sites tend to be coastal and accessible to birdwatchers. However, it is unclear why birds concentrate in these areas. Explanations include the need for an emergency landing site (i.e., “fire escape” sensu Mehlman et al. 2005), geographic constraints (i.e., relatively small areas of land adjacent to water), or the quality of habitat. While these explanations are not mutually exclusive, understanding the cause of the concentration pattern will be important in developing effective conservation and management plans. Away from immediate coastal areas, the emergency landing and geographic bottleneck components of stopover sites have less influence on migrant concentrations, whereas habitat quality may be a more important factor in determining where large numbers of migrating birds stop to rest and refuel. Unfortunately, identifying non-coastal landbird stopover concentration areas has been difficult due to accessibility, geographic extent, and the likelihood that they do not have “hard” boundaries. These characteristics make it extremely difficult to employ ground-based observation to identify and describe inland stopover concentration areas.

Weather surveillance radar was introduced to the ornithological community over fifty years ago as a valuable tool for observing migratory birds. The development and deployment of Doppler weather surveillance radar (NEXRAD, WSR-88D) across the United States in the mid-1990s created new opportunities for observing migration at large spatial and temporal scales. Sidney Gauthreaux and Carroll Belser of Clemson University and Ron Larkin, University of Illinois, pioneered the application of NEXRAD to the study of the spatial and temporal dynamics of landbird migration (Larkin 1991;

Gauthreaux and Belser 1998). Among the results of this early work was confirmation that migrating landbirds do concentrate in non-coastal areas. However, radar data are complex and influenced by dynamic temporal and three-dimensional spatial factors that can make interpretation difficult. Quantitative approaches to analysis of migratory bird patterns detected by radar have been developing slowly over the past decade (Diehl and Larkin 2005; Gauthreaux and Belser 1998; 2003; Mizrahi 2006). Despite these caveats, Doppler weather surveillance radar has been established as a tool with great potential for identifying and characterizing migratory landbird stopover concentration sites (Gauthreaux and Belser 2003; Diehl and Larkin 2005; Mizrahi 2006). The principle behind this application is that birds taking off on migratory flights are detected by the radar as they enter the atmosphere. The relative density of birds is registered as base reflectivity. Where migrants leave the landscape in large numbers, a high reflectivity "exodus signature" can be seen on a radar image (Fig. 1). Geo-referenced spatial models of these exodus signatures can then be used to investigate the habitat and landscape characteristics associated with migratory landbird stopover concentrations.

The Mid-Atlantic coastal plain contains several significant migratory bird stopover areas. Among these, the lower Delmarva Peninsula, located between the Chesapeake Bay and the Atlantic Ocean, is known to harbor millions of passage landbird migrants during fall migration (Watts and Mabey 1994), and it has been hypothesized that habitats of the Western Shore of the Chesapeake may harbor equal numbers of migrants (Watts, Wilson, and Paxton xx). Through a collaboration established in 2003 with funding from the US Geological Survey (USGS), the Virginia Department of Environmental Quality (VADEQ), Virginia Department of Game and Inland Fisheries (VADGIF), and The Nature Conservancy (TNC), we have employed an integrated approach to identifying and characterizing Neotropical migratory landbird stopover sites within the Lower Chesapeake Bay region for the purpose of supporting on-going regional conservation planning and management programs. This project evaluated the quantity and quality of existing stopover habitats for Neotropical migrant landbirds on the lower Delmarva Peninsula (from approximately Eastville, VA southward) and on the Western Shore of the lower Chesapeake Bay, at sites identified from analysis of Wakefield, VA, NEXRAD radar images. We are also integrating data from a high resolution transportable Doppler radar, the Oyster, VA-based NPOL radar operated by NASA, with data from field surveys of birds and detailed vegetation data to classify habitat patches on the lower Delmarva Peninsula according to use (distribution, abundance, and consistency over time) by migrating landbirds. Here we report results describing the association between stopover concentration sites and land cover for the Western Shore of the Chesapeake Bay and provide summaries of the component studies that form the basis for our on-going integrated analysis to be finalized by July 2007.

OBJECTIVES

The primary objective of this project is to provide information products that will improve the efficacy of conservation programs for Neotropical migrant landbirds in the lower Chesapeake Bay Region. Secondary objectives are to validate the wider application of NEXRAD radar in identifying significant migration stopover sites and to develop statistically rigorous approaches for field surveys of migrant bird abundance and distribution. Specific objectives included: (1) identify and prioritize stopover sites for Neotropical migrant landbirds within the lower Delmarva Peninsula and the lower Western Shore; (2) compare data collected by the Wakefield NEXRAD and the NPOL for the lower Western Shore; (3) validate radar results with concurrent ground surveys of birds on the lower Delmarva Peninsula; (4) complete status assessment of habitat availability and quality within identified significant stopover sites on the lower Western Shore; (5) develop guidelines to enhance habitat quality for migrants; and (6) apply project results to on-going efforts to conserve and enhance stopover habitats available to migrating birds in the lower Chesapeake Bay Region.

STUDY AREA

Our study was designed to identify stopover habitats used by migrating landbirds during the fall migration within the lower Chesapeake Bay Region, including the lower Delmarva Peninsula and the lower Western Shore counties of Virginia (Fig. 2). Each year millions of birds pass through the Mid-Atlantic Coastal Plain as they move between breeding areas in northeastern North America and wintering areas within either the southeastern United States or the New World tropics. The lower Delmarva and Cape May peninsulas are significant migration bottlenecks, concentrating large numbers of birds within relatively small land areas. Habitats on these peninsulas receive extremely high use by migrant landbirds during the fall months and are considered to have some of the highest conservation values in eastern North America (Mabey et al. 1993). Because of its critical importance, the lower Delmarva Peninsula is the subject of land protection and habitat restoration plans being developed by the US Fish and Wildlife Service (FWS), TNC, and other partner agencies.

The lower Delmarva Peninsula has remained relatively isolated and rural. Most of the upland portion of Northampton County, the southernmost county on the Peninsula, is in agricultural use (54%), with forest covering 38%. However, since the toll on the Chesapeake Bay Bridge-Tunnel was reduced in March 2002, the area is experiencing increasing development pressure, and many forest patches are in imminent danger of becoming lost or degraded. An impact study predicted that approximately 45% of the land in Northampton County will be converted to development in the near future. Development pressure will be greatest within the bayside corridor, which is considered to be the most critical stopover habitat (Watts and Mabey 1994). As land prices have escalated, bayside tracts are being subdivided at a rapid rate.

Large blocks of forest on the Western Shore of the lower Chesapeake Bay have been designated as priorities for conservation by TNC, FWS, and other conservation groups. TNC has two landscape scale habitat conservation programs in the region. The Green Sea program is focused on sites along the Northwest River, the North Landing River, the Chowan River basin, and the Great Dismal Swamp. The Chesapeake Rivers program is focused at action sites at Fort A.P. Hill, and along the Dragon Run/Mattaponi River, the middle Rappahannock River, and the Pamunkey River. However, the significance of these sites as stopover habitat for Neotropical migrant landbirds is not well understood.

There is some evidence that forested wetlands on the lower Western Shore provide critical stopover habitat for Neotropical migrant landbirds during the spring migration (Watts and Paxton unpubl.). Large tracts of forested wetlands occur throughout the region, especially in the south. Also within this project area is a good diversity of land cover that should allow for identification of factors associated with migrant bird abundance. Products from this project will be used to inform conservation action in the region.

METHODS

Identification of Important Stopover Sites on the Western Shore

NEXRAD Data Processing and Analysis--We analyzed NEXRAD (WSR-88D) data from the Wakefield, VA radar site (AKQ) for the fall migration seasons of 2003 and 2004, using base reflectivity data as a relative measure of migrant density. To increase our confidence that targets detected by the radar were birds emerging from stopover sites, we employed a two-step screening process for data captured by the AKQ WSR-88D 0.5 - 2.0 hr after sunset. First, we examined base reflectivity imagery, and selected nights with no weather contamination within 110 km of the radar station. Then, for each weather-free night, we recorded the direction and speed of the main vector of target movement from radial velocity imagery. These were compared to winds aloft measured at 925 mb (approximately 1000 m AGL), using wind data obtained from Plymouth State University (http://vortex.plymouth.edu/upairwx-u.html); targets were assumed to be migrating birds if they were moving in a seasonally appropriate direction at > wind speeds + 10 knots. Data for these nights were selected for analysis. Nights with disorganized velocities (i.e., no main vector) were not included in analyses.

We downloaded data for the selected nights from the NOAA's National Climatic Data Center (NCDC) and used the NCDC NEXRAD Data Exporter (http://www.ncdc.noaa.gov/oa/radar/jnx/) to translate radar data to an ESRI ASCII Grid format. We imported a single grid of radar base reflectivity data (dBZ) collected 30-40 min after sunset for each night into ArcGIS 8.2 and reclassified data to a positive scale. We selected a random sample of valid nights during the peak of long-distance migrant passage, set as September 1 – October 15 (Watts and Mabey 1994). A total of 9 nights/year (n = 18) were included in the analysis.

Weather surveillance radar data contain two inherent limitations related to detection of bird targets. The altitude of the radar beam relative to the earth's surface and the volume of atmosphere sampled both increase with distance from the radar (Fig. 3). Close to the radar, where the beam is low to the earth's surface, biological targets are usually obscured by ground clutter (e.g., trees, buildings). As the radar beam spreads and increases in altitude, the reflectivity signal weakens (Fig. 3). At a distance of about 110 km, NEXRAD can no longer reliably detect birds because the beam altitude is above the maximum flight altitude for the majority of migrating birds. To control for the inherent distance detection problems, we excluded an area around the radar with a radius of 15 km to eliminate ground clutter and reclassified reflectivity data based on a distance-specific ordinal scale of target density. We sectioned each radar scan into 18 concentric 5-km rings radiating from15 km to 105 km from the radar (Fig. 4). We summed reflectivity values of grid cells (rasters) within each distance ring across the 18 selected nights, using the ArcGIS raster calculator to obtain a 2-yr cumulative reflectivity ("exodus") value. We reclassified the 2-yr cumulative values within each ring to a quantile scale with 5 % breaks (i.e., quantiles were based on the range of values within a given distance ring) (Fig. 5). Quantiles of the same value from different distance rings represent the same level of relative reflectivity. For example, the 50th percentile represents those areas that exhibit reflectivity values above the median. We stress that this approach only allows for relative ranking of exodus values within the AKQ scan area. We merged the reclassified distance rings and smoothed the raster surface using neighbor statistics in ArcGIS Spatial Analyst. We set raster size at 1.65 km2 to reflect an area larger than the largest radar sampling bin within our analysis area. Areas of "no data" did not contribute to raster sums. The resulting geo-referenced dataset reflects spatial variation in accumulated migrant density within the area of radar coverage, restricted by the coastline of the Chesapeake Bay to the east and the edge of the Piedmont (Fall Line) to the west (Figs. 6 & 7).

Stopover concentrations and their habitats --We used the 65th percentile of migrant density (i.e., all areas registering in the top 35% of cumulative reflectivity values) as an arbitrary cut-off for the baseline value for identification of stopover concentration areas. We further sub-divided the stopover layer at each 5% increment of the quantile scale into stopover concentration zones representing increasing cumulative migrant density (Fig. 7). We evaluated the relationship between stopover concentration zones and habitat by overlaying the stopover layer on geo-referenced land cover data from the 2001 National Land Cover Database (NLCD) (Fig. 8), and comparing the area of each land cover class within each stopover concentration zone to the total available area of each land cover class within the study region, using a Chi-square goodness of fit test (Zar 1996). Within the 65th percentile stopover zone, we identified all stopover concentration areas covering more than 10,000 contiguous acres (Fig. 9). We examined the habitat characteristics of these sites by comparing the area of each land cover class to the total available area of each land cover class within the study region using a Chi-square goodness-of-fit test. Open water was excluded from these analyses to eliminate bias that might arise from inclusion of a common land cover class that cannot be used as stopover habitat by Neotropical landbird migrants.

We used the 65th percentile stopover zone to examine regional patterns of landbird migrant exodus and current extent of conservation lands. We used data available from the Virginia Department of Conservation and Recreation, Natural Heritage Program (http://192.206.31.52/cfprog/conslands/login.cfm) to create a layer showing lands owned by conservation organizations or agencies or protected under easements through the Virginia Outdoors Foundation. A simple visual overlay allows for assessment of spatial correspondence between the stopover concentration zone and protected areas.

Identification of Important Stopover Sites on the Lower Delmarva Peninsula

Land Cover Map -- A GIS coverage of forested habitats available to migrants stopping over on the lower Delmarva Peninsula (Northampton County, VA) was prepared from digital orthophotos (1994 Virginia DOQQ and 2002 Virginia base map) and field vegetation data. Forest patch attributes measured include area, perimeter, patch center coordinates, distance to the nearest 5 patches, composition, density, and age.

NPOL Data Collection and Processing -- The NPOL radar collected data for this study on a total of 96 nights (52 nights in 2004 and 44 nights in 2005). We screened imagery for weather contamination and target velocity as described for NEXRAD data, and identified 66 nights from which we could sample data. Within a single night of radar data, we sub-sampled a total of seven scans corresponding with periods of exodus (i.e., within the first 30 min after sunset when birds are expected to be leaving the landscape) and migration traffic (i.e., 2-4 hr after sunset when birds from the region would be expected to be flying over the peninsula). On some nights, weather contamination or false echoes on radar imagery affected one of the sub-sample periods, eliminating inclusion of data for one but not the other period. As a result, we have a total sample size of 58 nights for exodus data and 63 nights for traffic data. Data from each radar scan in our sub-sample have been processed to create data files that can be projected and analyzed in a GIS, using the UF Exporter program developed at North Carolina State University (see Appendix C).

Ground Surveys of Birds -- Field surveys of birds were conducted to ground-truth the NPOL radar data. A capture-mark-recapture/re-sight study was conducted on Fisherman Island National Wildlife Refuge to collect data for estimation of migrant abundance and exodus; birds were also captured and banded at the long-term banding station at Kiptopeke State Park. Counts of birds were conducted in 32 forest patches in southern Northampton County and in scrub habitats on the Eastern Shore of Virginia National Wildlife Refuge, to sample the spatiotemporal distribution and habitat associations of migrants. Vegetation characteristics were sampled at the scrub points and in the forest patches across Northampton County, providing co-variates for statistical analyses of the spatial distribution and abundance of migrants. Field data were digitized in preparation for analyses to identify vegetation, site, and landscape characteristics associated with migrant presence and abundance, and to correlate with radar estimates of the spatial and temporal distribution and abundance of migrants emerging from stopover sites.

Development of Management Guidelines

Guidelines are needed to manage habitats to produce the highest quality stopover habitat possible within the project area and elsewhere. Data from Fall 2003-2004 field surveys and earlier survey data from Lower Delmarva (Watts and Mabey 1994, Watts and Paxton 2001) will be integrated with radar data to further refine relationships between vegetation characteristics, energy resources (insects and fruit), and migrants. Such prescriptions are useful in the management of existing refuge lands, establishment of conservation easements, and the promotion of best management practices on private lands.

RESULTS

Important Stopover Sites on the Western Shore

Almost half of the Wakefield NEXRAD scan area (105 km radius, total area = 8,860,378 acres) is associated with at least moderate migrant exodus densities as depicted by the 50th percentile zone (Fig. 6). The largest contiguous area of high migrant densities appears to occur west of Richmond and Petersburg on the eastern edge of the Piedmont. This pattern may be influenced by the land elevation gain and lower height of the radar beam relative to the ground west of the Fall Line. We did not analyze land cover associations for this area. Within the Western Shore study region, areas of highest migrant densities appear to be associated with the Great Dismal Swamp, the Chowan/Meherrin/Blackwater river system, the upper James River, and the Middle Peninsula (Fig. 7).

Land cover classes show distinct patterns within the Western Shore study region, with agricultural lands and forested wetlands common in the southeast, developed land concentrated at the mouth of the James River, deciduous forest common in the north, and evergreen forest common in the southwest (Figs. 10 & 11). The overlay of the 65th percentile stopover concentration zone with land cover data suggests that there is a positive correspondence between migrant stopovers and woody wetlands and deciduous forest, and a negative correspondence with developed and agricultural areas (Fig. 10 & 11). Analysis of land cover within stopover concentration zones indicates a significant deviation from available land cover (Fig. 12). Distributions of observed land cover classes within stopover concentration zones (65th – 95th percentile zones) differ from expected for all migrant density levels (Table 1; Chi-square values all > 1500; df = 12; $p < 0.001$). The largest deviations are seen in greater than expected associations with woody wetland and deciduous forest, and lower than expected associations with evergreen forest, agricultural land, and developed areas.

Each of the ten largest contiguous stopover areas within the 65th percentile concentration zone also exhibit land cover class associations that deviate significantly from expected based on available area of cover classes (Table 2; Chi-square values all > 1500; df = 12; $p < 0.001$). Each stopover area has a unique profile but the general pattern appears to be a positive relationship between migrant use and woody wetlands in the southern areas and a stronger positive relationship with deciduous forest in the northern areas (Fig. 13). The Franklin, Back Bay, and Back Bay South stopover areas all contain more developed and agricultural land than expected and weak or negative associations with woody wetlands and deciduous forest (Table 2).

Visual assessment of the correspondence between conservation lands and the 65th percentile stopover concentration zone indicates that the majority of stopover areas within our Western Shore study region are not currently protected (Fig. 14).

Identification of Important Stopover Sites on the Lower Delmarva Peninsula

Digital copies of the Northampton County baseline habitat assessment and land cover map layers and accompanying detailed metadata are included with the submission of this report. Initial analysis of the NPOL radar data has shown some unanticipated results, arising from the spatial distribution of ground clutter and interference in the scans. To address these problems, we are currently exploring a variety of statistical methods for describing the data, identifying patterns of exodus, and relating NPOL data to ground-based surveys. We include a map (Fig. 15) depicting exodus activity 30 min after sunset standardized to a quantile scale generated as described for NEXRAD, using 3 km distance rings across a scan radius of 5-35 km from NPOL. We present these maps primarily to illustrate areas of missing data and demonstrate that our proposed approach to the NPOL data has required significant modification. We are unable to use data from the NPOL to cross-validate data from the Wakefield NEXRAD because of the poor overlap in coverage and the unanticipated distance decay factor associated with the NPOL data.

Detailed summaries of field surveys of birds conducted during the fall migration seasons of 2003-2005 can be found in Appendix A and Appendix B. Recaptures and sightings of birds on Fisherman Island were not sufficient to estimate migrant abundance and exodus, but capture data can contribute to correlations of field data with radar data. Further progress on this integrated analysis will be made as soon as the on-going quantitative analysis of NPOL data is complete. We will incorporate the complete integrated results into the brochure containing guidelines to manage habitats to benefit landbirds on migration stopover, for distribution to a wider audience. A full report of relationships between radar data, migrant ground surveys, and vegetation data will be submitted as an addendum to this report, no later than August 2007.

DISCUSSION

Results from two fall migration seasons indicate that migratory landbirds are not evenly distributed across the lower Western Shore of the Chesapeake Bay. The landscapes underlying areas of relatively high cumulative migrant densities are generally characterized by a high proportion of woody wetlands and/or deciduous forest and a low proportion of evergreen forest, agricultural land, and developed land (Fig. 12). This association appears to strengthen with increasing levels of migrant use (Table 1). This suggests that migratory landbirds stopping-over within the Western Shore region may preferentially select woody wetlands and deciduous forests during fall migration. It may also indicate that woody wetland and deciduous forest habitats contain resources that can support greater numbers of passage migrants than other habitats in this regional landscape.

These results contrast slightly with the findings reported by Mizrahi (2006) for the upper Delmarva Peninsula. Using data collected from the Dover, DE NEXRAD, Mizrahi found strong associations between stopover concentration areas and woody wetlands during spring migration but not fall. In the fall, Mizrahi reports stopover concentration areas tend to be characterized by a high proportion of deciduous forest whereas woody wetlands were of lower importance. We found clear evidence that both habitat types are important to migratory landbirds during stopover. Our study region contains several extensive forested wetland systems including the Great Dismal Swamp and those associated with the Chowan, James, and York Rivers. Although we did not assess the relationship between migrant density and habitat patch size, the size of the woody wetlands within our study region may be a factor in their strong association with stopover concentration areas.

When we analyzed the land cover characteristics of the ten largest contiguous stopover areas within the 65th percentile concentration zone, we found that woody wetlands and deciduous forests the two most important habitat types. However, we also found that land cover characteristics varied from area to area. There is an obvious north-south pattern in the land cover with northern sites containing relatively high proportions of deciduous forest and the southern sites containing relatively high proportions of woody wetlands.

Surprisingly, three of the largest stopover areas (Franklin, Back Bay, and Back Bay South) have land cover profiles that do not conform to the general picture exhibited by the other large stopover areas or the stopover concentration zones (Tables 1 & 2). All three sites have less deciduous forest than available within the region as a whole. Back Bay and Franklin have only slightly more woody wetland than expected and Back Bay South has slightly less woody wetland than expected. All three sites contain a high proportion of agricultural land and Back Bay and Franklin contain high proportions of developed land compared to the surrounding region. We suggest three possible explanations for the unique land cover profiles of Franklin, Back Bay and Back Bay South. (1) These three areas may act as important concentration sites for a different set of migratory species, specifically grassland species that might prefer to stopover in agricultural fields and herbaceous wetlands. (2) Relatively high migrant use of these three areas may be influenced by geographic location rather than habitat. This seems most likely for Back Bay and Back Bay South that are close to the Atlantic Coast and may act as “fire escapes.” Or, (3) the small area of woody wetlands within each site supports a relatively greater density of migrants than equal areas of woody wetland contained in other sites. Ground-based surveys and more detailed radar data analysis would help explain these three outliers.

A qualitative assessment of correspondence between stopover concentration areas and lands under current conservation management indicates that only a small proportion of migratory landbird stopover habitat within the lower Western Shore region is protected. The Great Dismal Swamp stands out among those areas already protected. This large forested wetland system may act as a “full-service hotel” (*sensu* Mehlman et al 2005), providing abundant resources for a large range of species. Based on the results of this study, we recommend that conservation plans for this region should prioritize woody wetland and deciduous forest habitats, specifically targeting sites covered by the ten largest stopover concentration areas.

NEXRAD Doppler weather surveillance radar has valuable potential as a conservation tool. The ability to detect exodus events over large spatial scales allows us to model variation in migrant density across broad regions. These spatial models can then be used to identify areas of greatest migrant use. However, it should be noted that the nature of radar data results in models with relatively low spatial resolution. That is, the models presented represent stopover concentration "envelopes" that contain areas of high migrant use. With current analytic methods, NEXRAD data do not allow for exact pinpointing of stopover sites. Given the dynamic nature of migration and stopover events and the strong influence of weather on where and when migrants stop to rest and refuel, broadly defined stopover concentration zones may be the most appropriate approach for conservation planning within non-coastal areas.

ACKNOWLEDGEMENTS

We would like to recognize the significant contribution of the TRMM Radar Group, Observational Science Branch, Wallops Flight Facility, National Aeronautic and Space Administration for the use and operation of the NPOL radar. Lester Atkinson, Nathan Gears, and Michael Watson operated the radar at Oyster, supplied radar data archives, and provided invaluable advice throughout this project. This project and related work received additional funding and/or matching support from the VA Dept. of Game and Inland Fisheries (State Wildlife Grant), VA Dept. of Environmental Quality Coastal Program (NOAA Coastal Zone Management Act grant), The Nature Conservancy, Norfolk Foundation, Darden Family Foundation, Mary Flagler Cary Trust, and the David H. Smith Conservation Research Fellowship from the Cedar Tree Foundation (formerly the David H. Smith Foundation). Generous logistical support was provided by the staff of the Eastern Shore Wildlife Refuge, the Virginia Coast Reserve (TNC), the Chesapeake Bay Bridge Tunnel, and the North Carolina Fish and Wildlife Research Unit.

Maps contained within this report were produced by Bart Paxton, Center for Conservation Biology, College of William and Mary.

LITERATURE CITED

Diehl, R. H. and R. P. Larkin. 2005. Introductio to the WSR-88D (NEXRAD) for ornithological research. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.

Gauthreaux, S. A. and C. G. Belser. 1998. Displays of bird movements on the WSR-88D: Patterns and quantification. Weather and Forecasting 13: 453-464.

Gauthreaux, S. A., Jr. and C. G. Belser. 2003. Radar ornithology and biological conservation. The Auk 120: 266-277.

Homer, C., C. Huang, L. Yang, B. Wylie and M. Coan, 2004. Development of a 2001 national land cover database for the United States. Photogrammetric Engineering and Remote Sensing Vol.70,No.7,pp 829-840 or online at www.mrlc.gov/publications. The USGS acknowledges the support of NARSAL at the University of Georgia in development of data in this zone.

Larkin, R. P. 1991. Sensitivity of NEXRAD algorithms to echoes from birds and insects. In: 25th International Conference on Radar Meteorology. Paris, France: American Meteorological Society; 203-205.

Mabey, S. E., J. McCann, L. J. Niles, C. Bartlett, P. Kerlinger. 1993. The Neotropical Migratory Songbird Coastal Corridor Study Final Report. VA DEQ Report to the National Oceanic and Atmospheric Administration. NOAA Award No. NA90AA-H-CZ839. Richmond, VA. 71 pp.

Mehlman, D. W., S. E. Mabey, D. N. Ewert, C. Duncan, B. Abel, D. Cimprich, R. D. Sutter, and M. Woodrey. 2005. Conserving stopover sites for forest-dwelling migratory landbirds. The Auk 122: 1281-1290.

Mizrahi, D. S. 2006. Oases along the flyway: preserving critical stopover habitat for migrating songbirds on the Delmarva Peninsula. Report to U.S. Fish and Wildlife Service, Delaware Bay Project Office, Smyrna, DE.

Paxton, B. J. and B. D. Watts. 2001. Fall stop-over ecology of neotropical migrants: Are inner or outer coastal habitats energy sources for migrants. Center for Conservation Biology Technical Report CCBTR-01-10. College of William and Mary, Williamsburg, VA. 46 pp.

Sherry, T. W. and R. T. Holmes. 2000. Demographic modeling of migratory bird populations: The importance of parameter estimation using marked individuals. Pp 211-219 in Strategies for Bird Conservation: The Partners in Flight Planning Process (R. Bonney et al, eds.). USDA Forest Service Proceedings RMRS-P-16, Rocky Mountain Research Station, Ogden, Utah.

Sillett, T. S. and R. T. Holmes. 2002. Variation in survivorship of a migratory songbird throughout its annual cycle. Journal of Animal Ecology 71: 269-308.

Watts, B. D. and S. E. Mabey. 1994. Migratory landbirds of the lower Delmarva: Habitat selection and geographic distribution. Center for Conservation Biology Technical Report CCBTR-94-05. College of William and Mary, Williamsburg, VA. 101 pp.

Zar, J. H. 1996. Biostatistical Analysis, Third Edition. Prentice Hall, Upper Saddle River, NJ. 662 pp.

FIGURES AND TABLES

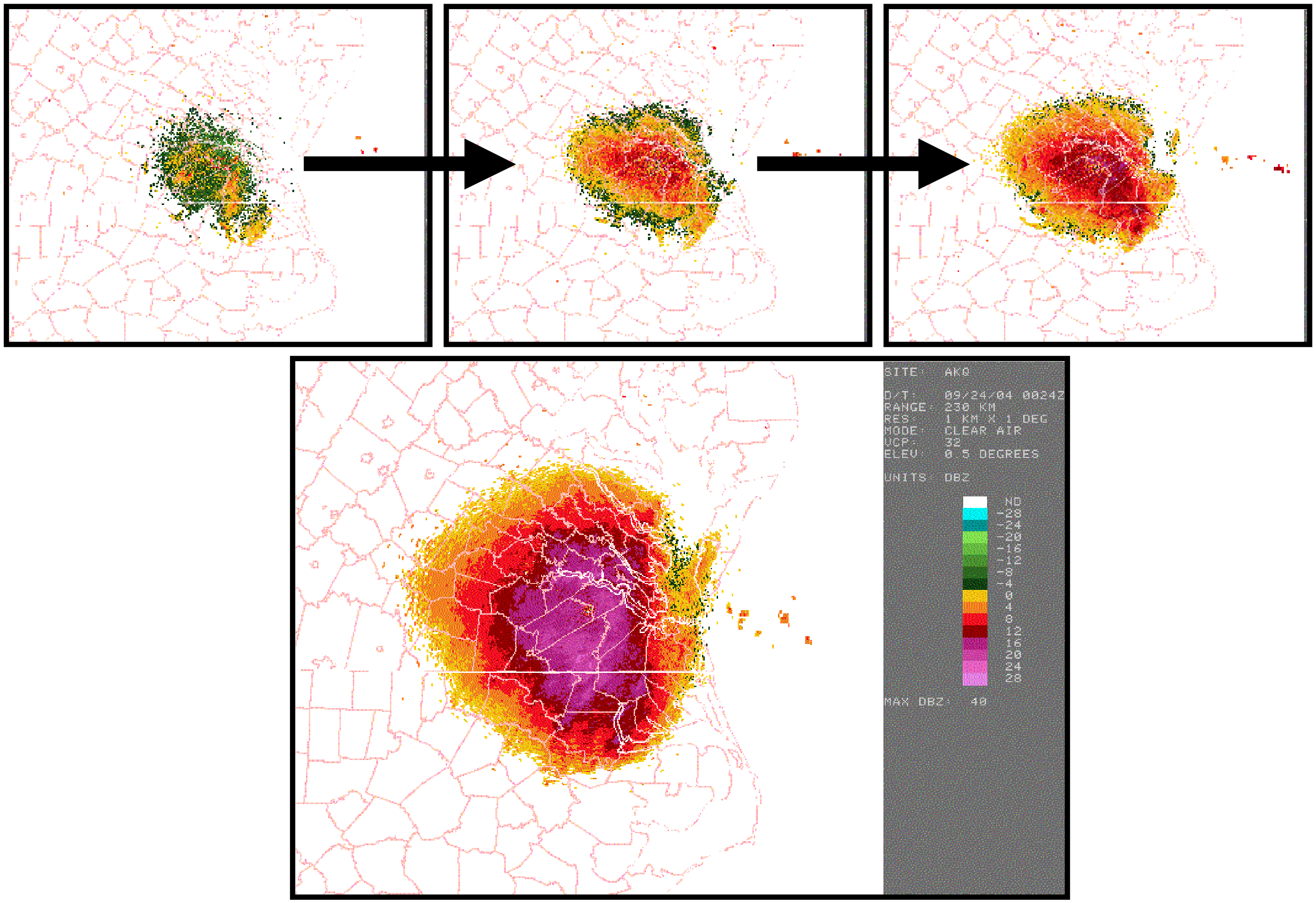


Figure 1. Figure 2. Temporal progression of migrants emerging from the landscape as recorded by the Wakefield, VA NEXRAD. Initial image from a scan approximately 15 min after sunset; next two images taken after successive 20 min intervals. The last image taken 40 min after the third (approximately 1.5 hr after sunset). The final image depicts "saturation" of the radar's ability to detect further increases in numbers of biological targets in the atmosphere.

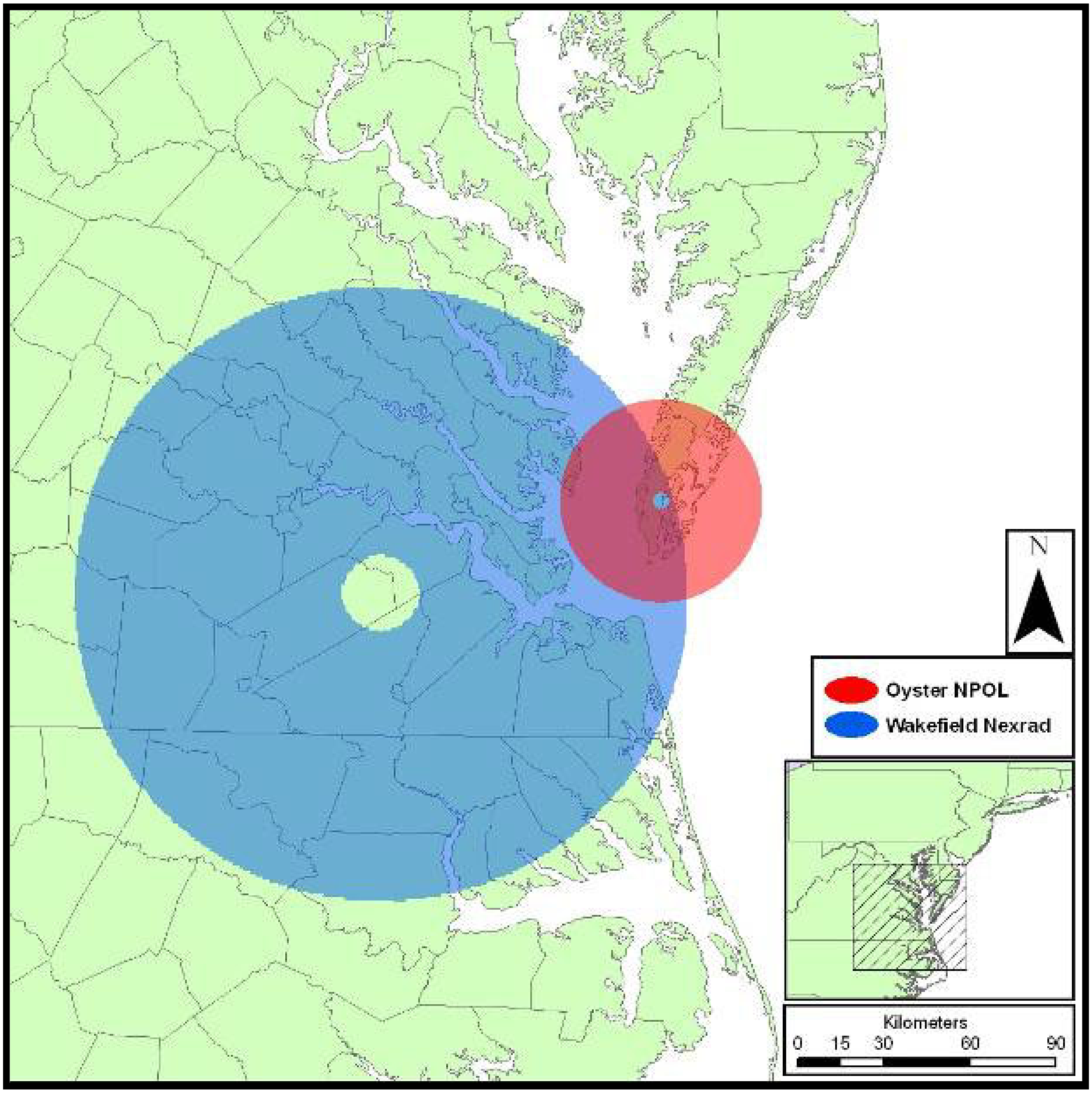


Figure 2. Study region for migrant landbird stopover habitat assessment and prioritization showing effective bird observation areas for the Wakefield, VA NEXRAD (radius 105 km; clutter hole radius 15 km) and NPOL based in Oyster, VA (radius 35 km; clutter hole radius 3 km). Clutter rings are area around the radar that must be eliminated because of interference from ground clutter (e.g., trees and buildings).

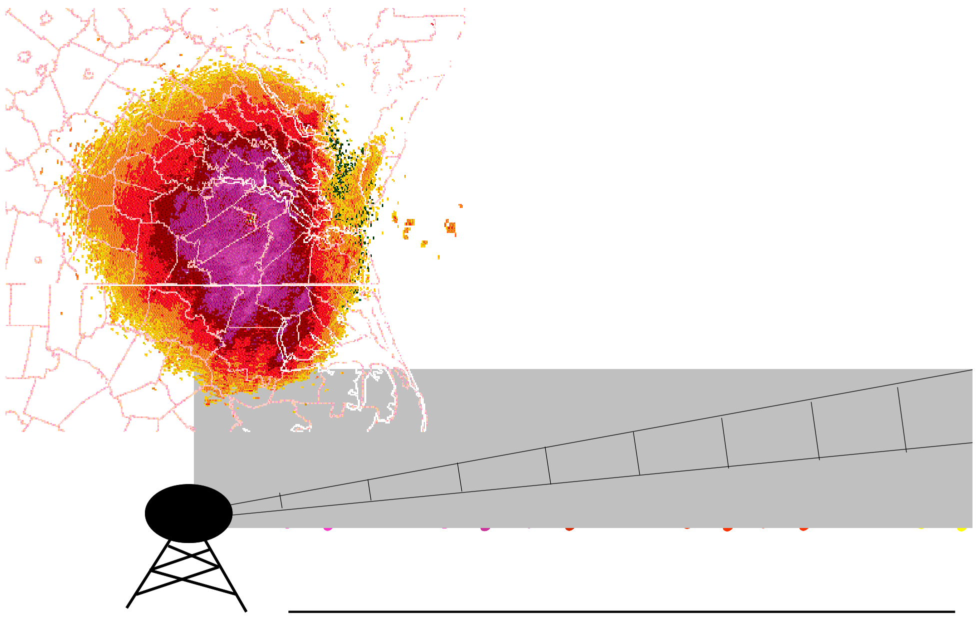


Figure 3. Degradation of detection with increasing distance from radar. Saturation images of bird targets usually depict a series of irregular concentric rings with the highest reflectivity values recorded close to the radar and increasingly weaker returns at more distant sites.

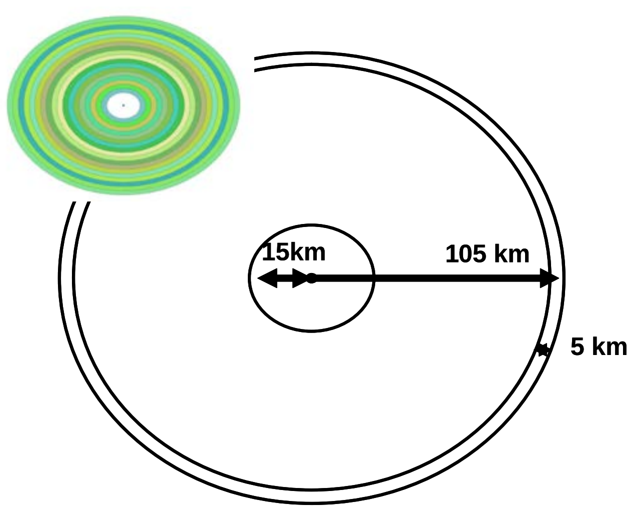


Figure 4. Distance correction for NEXRAD reflectivity data. To account for the signal degradation of NEXRAD data, we divided the scan area into concentric 5 km rings, summed reflectivity values within rings, and adjusted values within each ring to a percentile scale. Thus, the highest values among the relatively low values of the outer rings are weighted. The percentile scale is based on values within a single ring but common across the entire scan area.

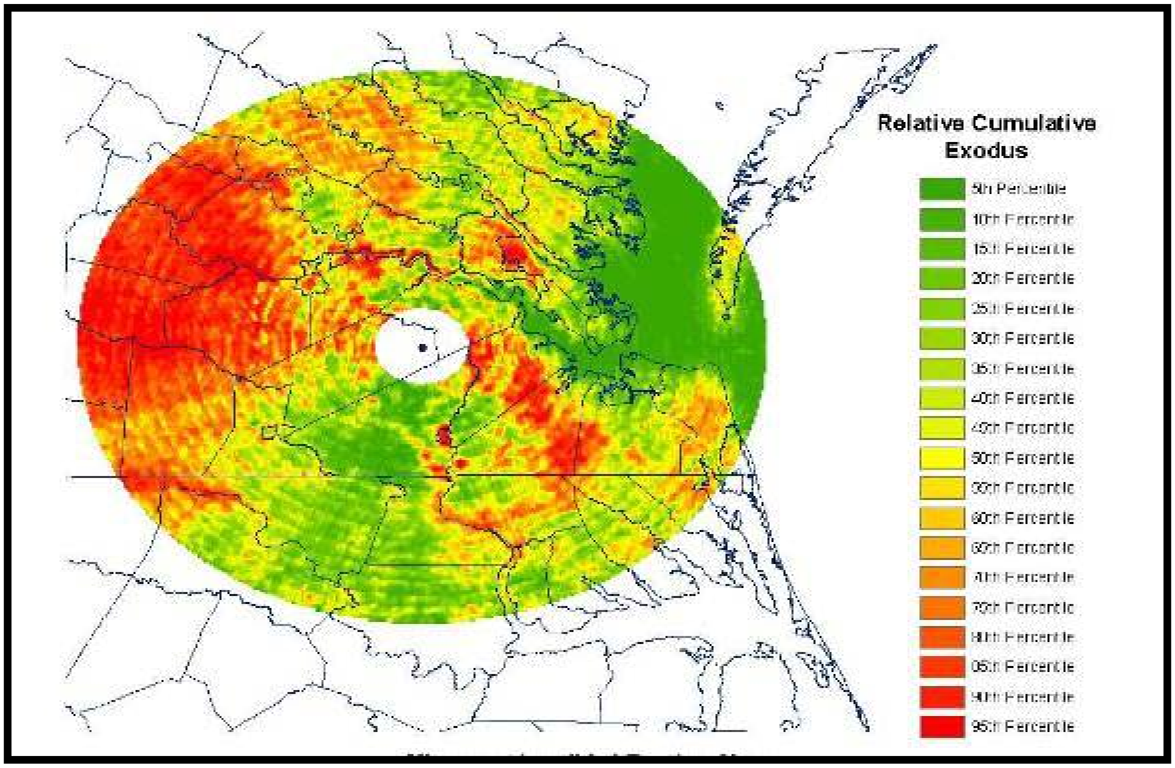


Figure 5. Reclassified cumulative reflectivity data from Wakefield, VA NEXRAD (Fall 2003 and 2004, n = 18 nights).

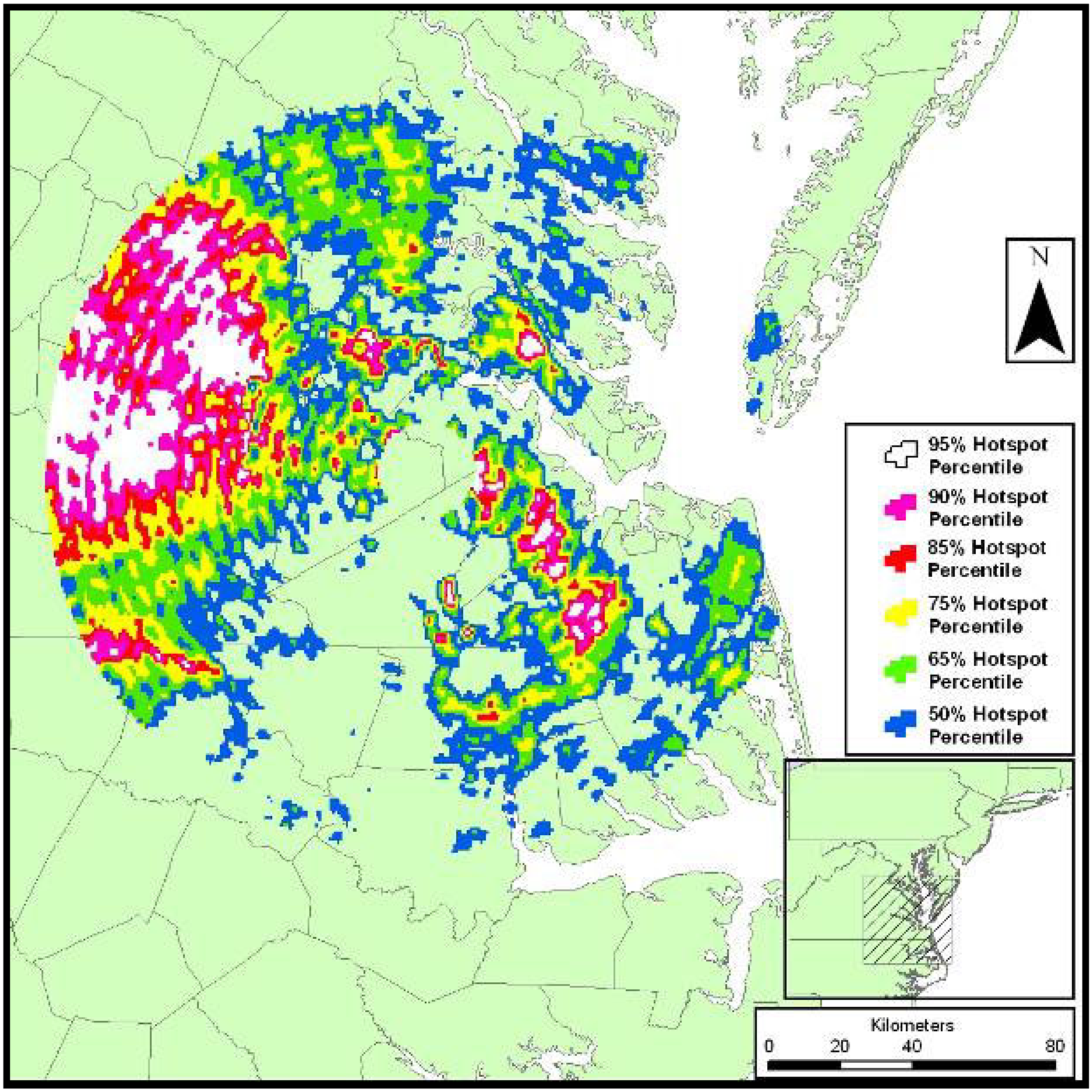


Figure 6. Cumulative reflectivity values for Wakefield, VA NEXRAD, fall 2003 and 2004. Scans taken an half hour after sunset on nights that passed screening criteria from two seasons were summed and adjusted to a common scale of relative cumulative reflectivity as a surrogate for target (bird) density. Areas described by percentiles indicate stopover hotspot zones with cumulative reflectivity values above 50-95% of all values recorded.

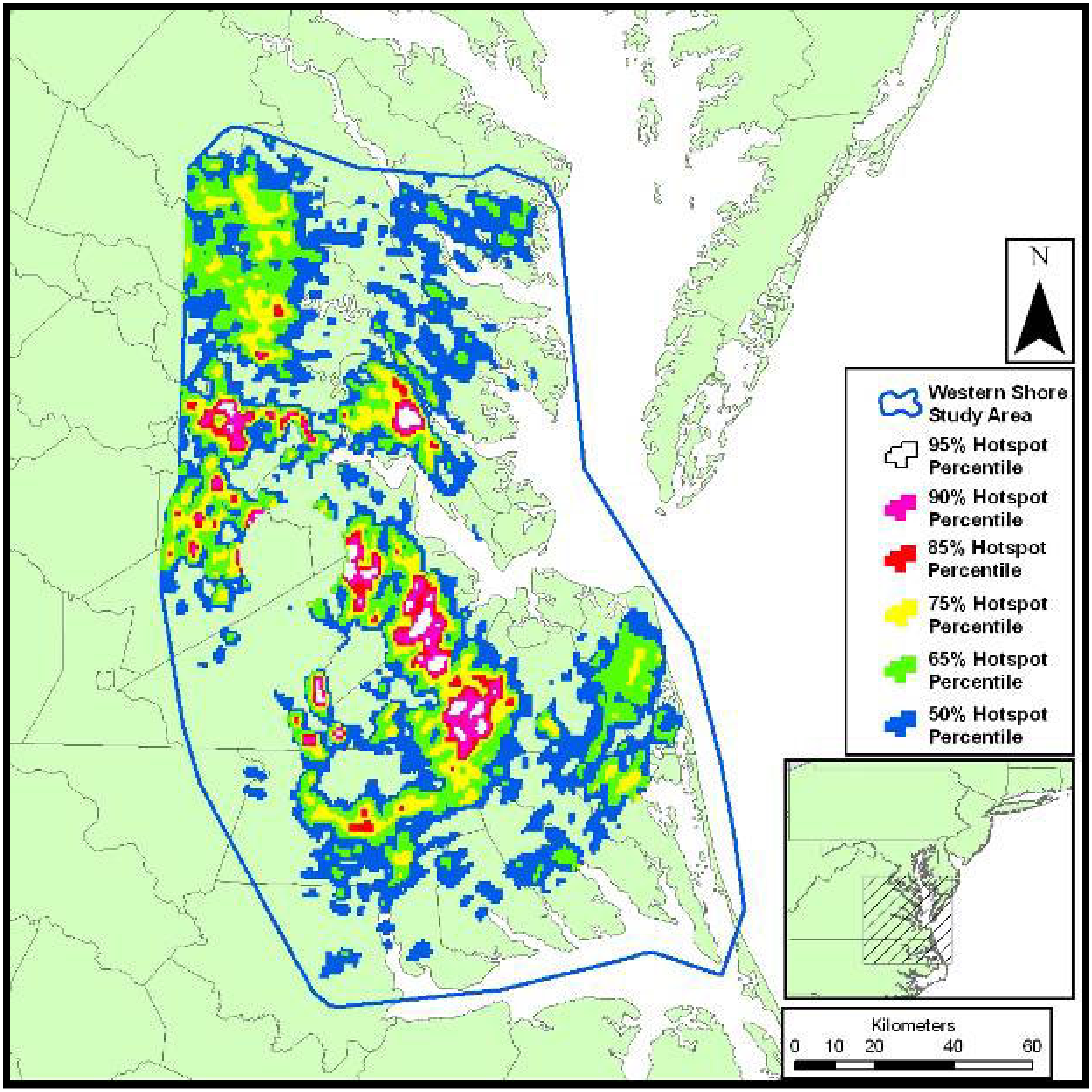


Figure 7. Cumulative reflectivity values for Wakefield, VA NEXRAD, fall 2003 and 2004 within the Western Shore study region. Scans taken an half hour after sunset on nights that passed screening criteria from two seasons were summed and adjusted to a common scale of relative cumulative reflectivity as a surrogate for target (bird) density. Areas described by percentiles indicate stopover hotspot zones with cumulative reflectivity values above 50-95% of all values recorded within the entire analysis radius.

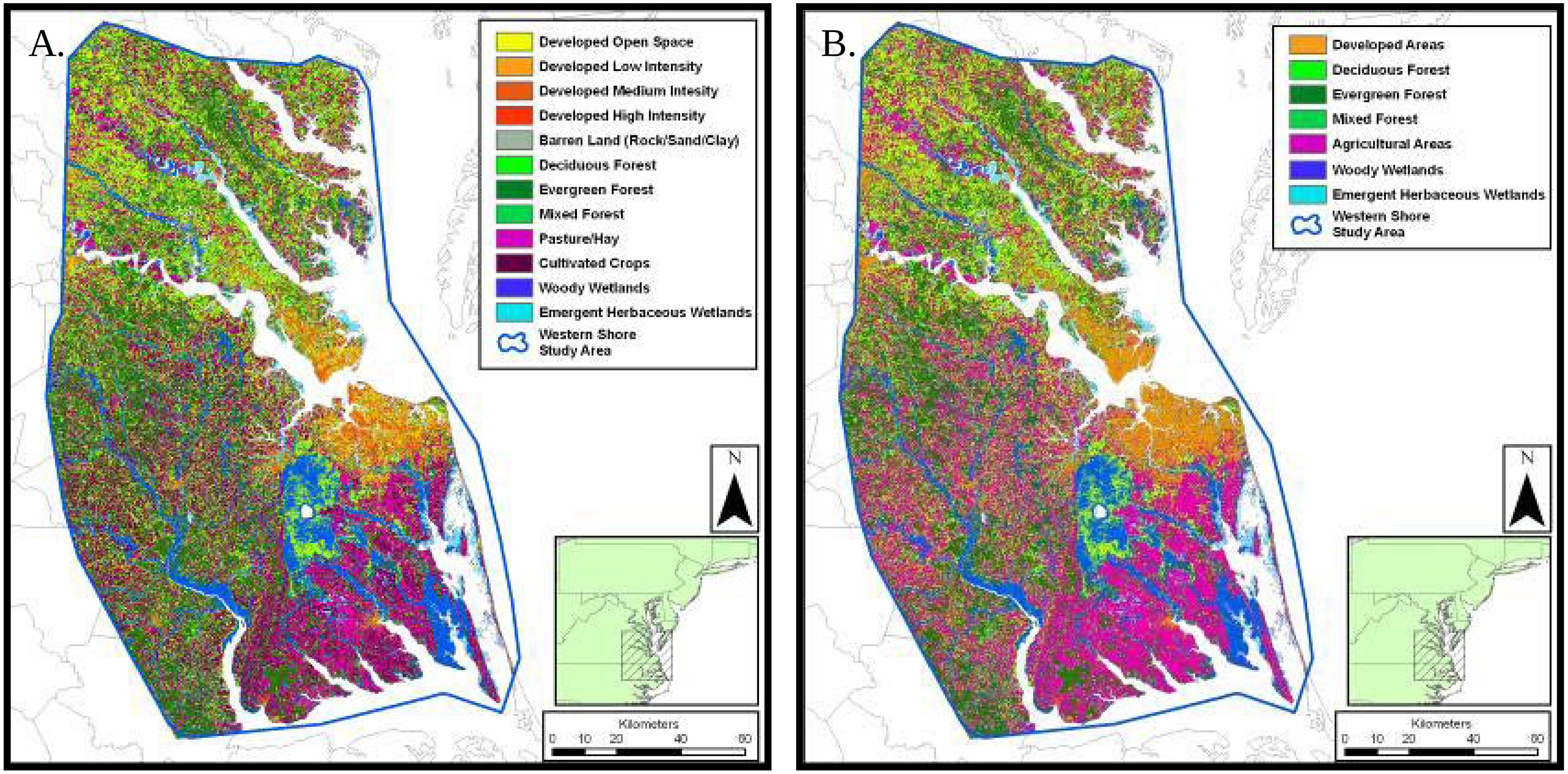


Figure 8. Land cover for Western Shore study area comparing coverage for complete classification (Map A) and lumped classification (Map B). Open water has been removed from both classifications. Classification from the National Land Cover Database, USGS (Homer et al. 2004).

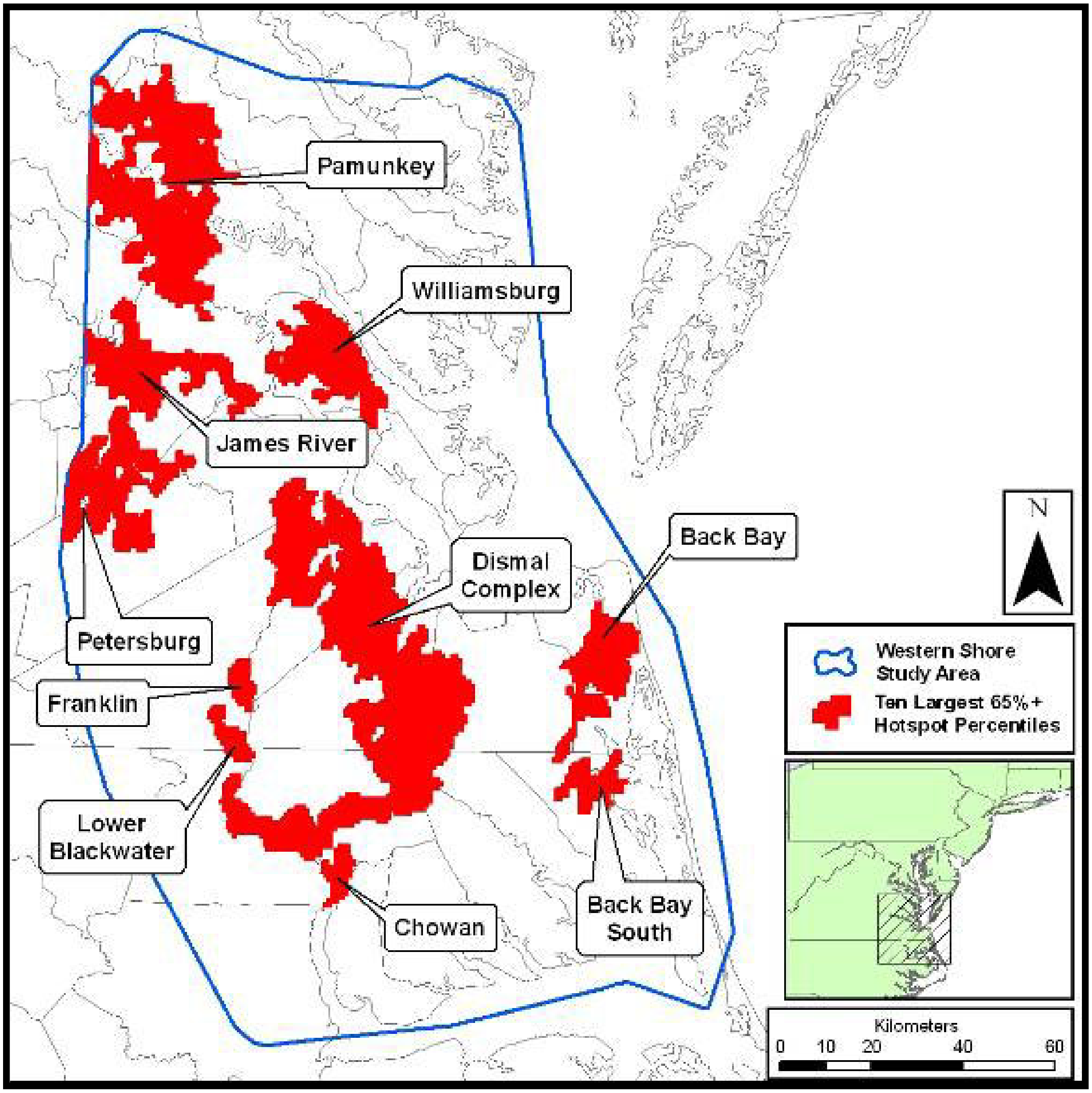


Figure 9. Largest contiguous stopover areas within the 65th percentile zone. The area defined by two year cumulative reflectivity data falling above the 65th percentile shows distinct and large contiguous areas generating strong exodus patterns. An arbitrary cut-off of 10,000 acres was used to identify the ten largest contiguous sites for further land cover analysis.

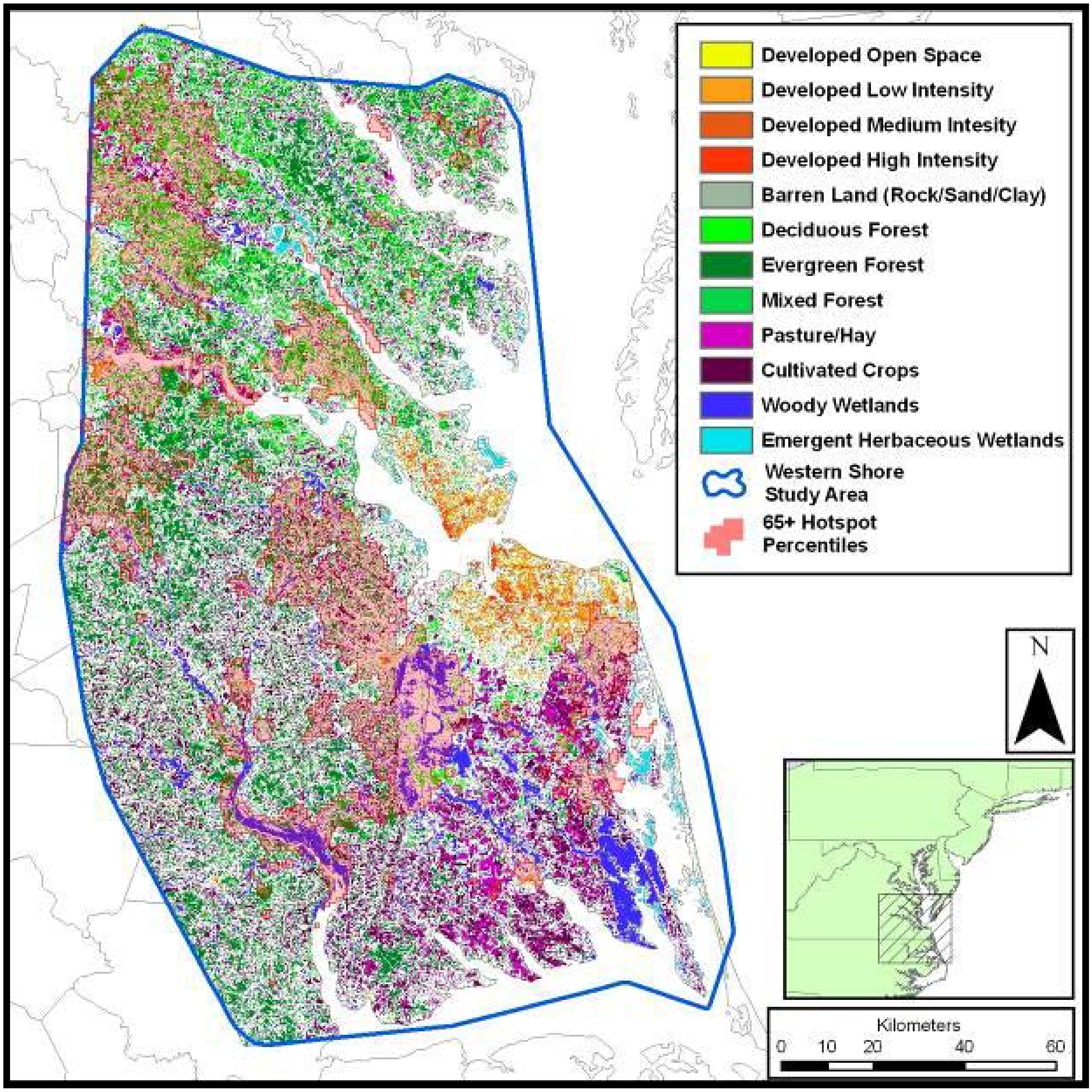


Figure 6. Spatial correspondence of 65th percentile stopover zone and land cover types for the Western Shore study region. Stopover zone shown as pink overlay illustrates the significant association between migratory landbird exodus activity recorded by NEXRAD and woody wetlands and deciduous forest. Developed land, agriculture, and evergreen forests are significantly underrepresented within the 65th percentile stopover zone. Open water has been removed from land cover classification. Classification from the National Land Cover Database, USGS (Homer et al. 2004).

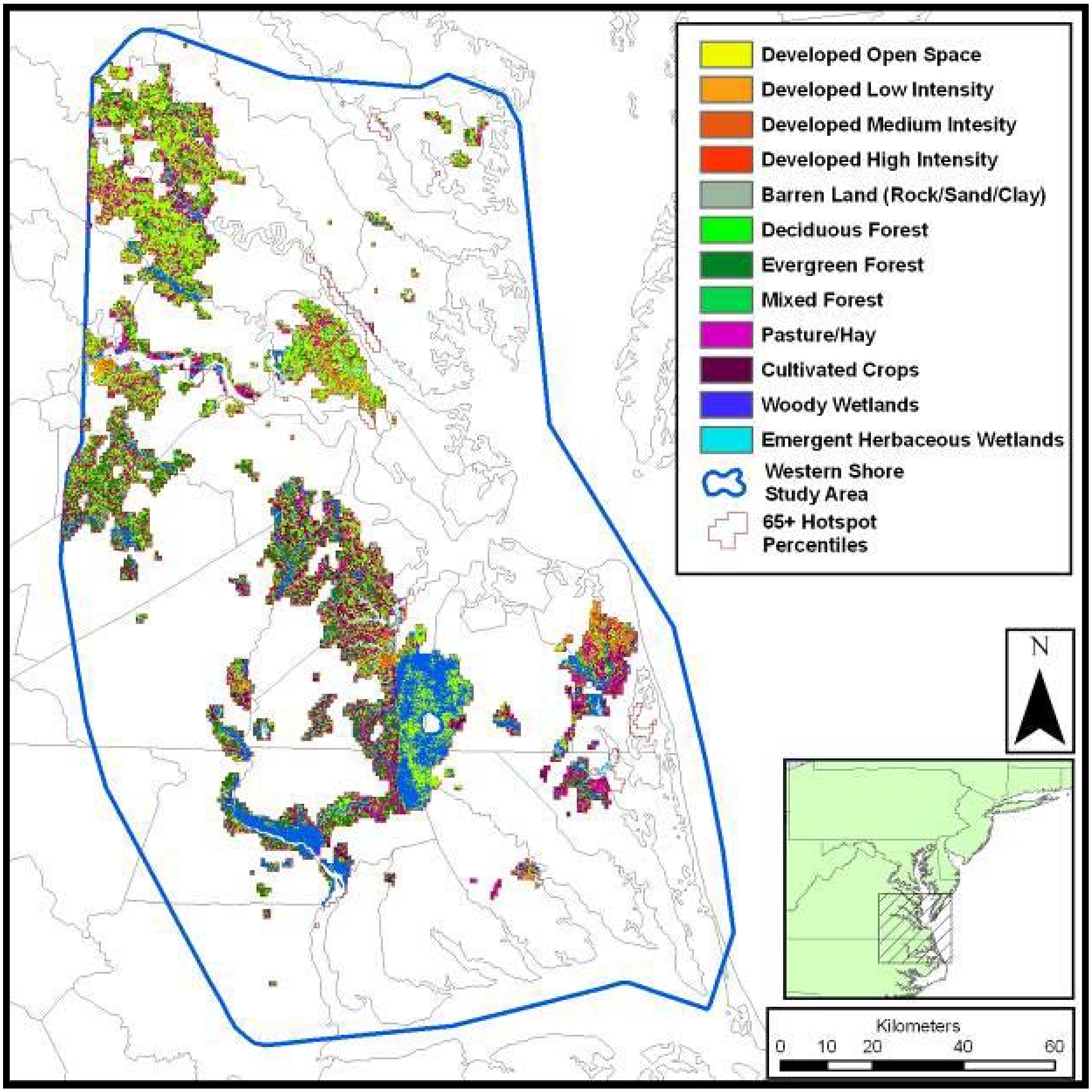


Figure 7. Land cover types within the 65th percentile stopover zone for the Western Shore study region. Southern stopover sites within the study region are characterized by extensive woody wetlands. Northern stopover sites within the region are primarily characterized by deciduous forest. Open water has been removed from land cover classification. Classification from the National Land Cover Database, USGS (Homer et al. 2004).

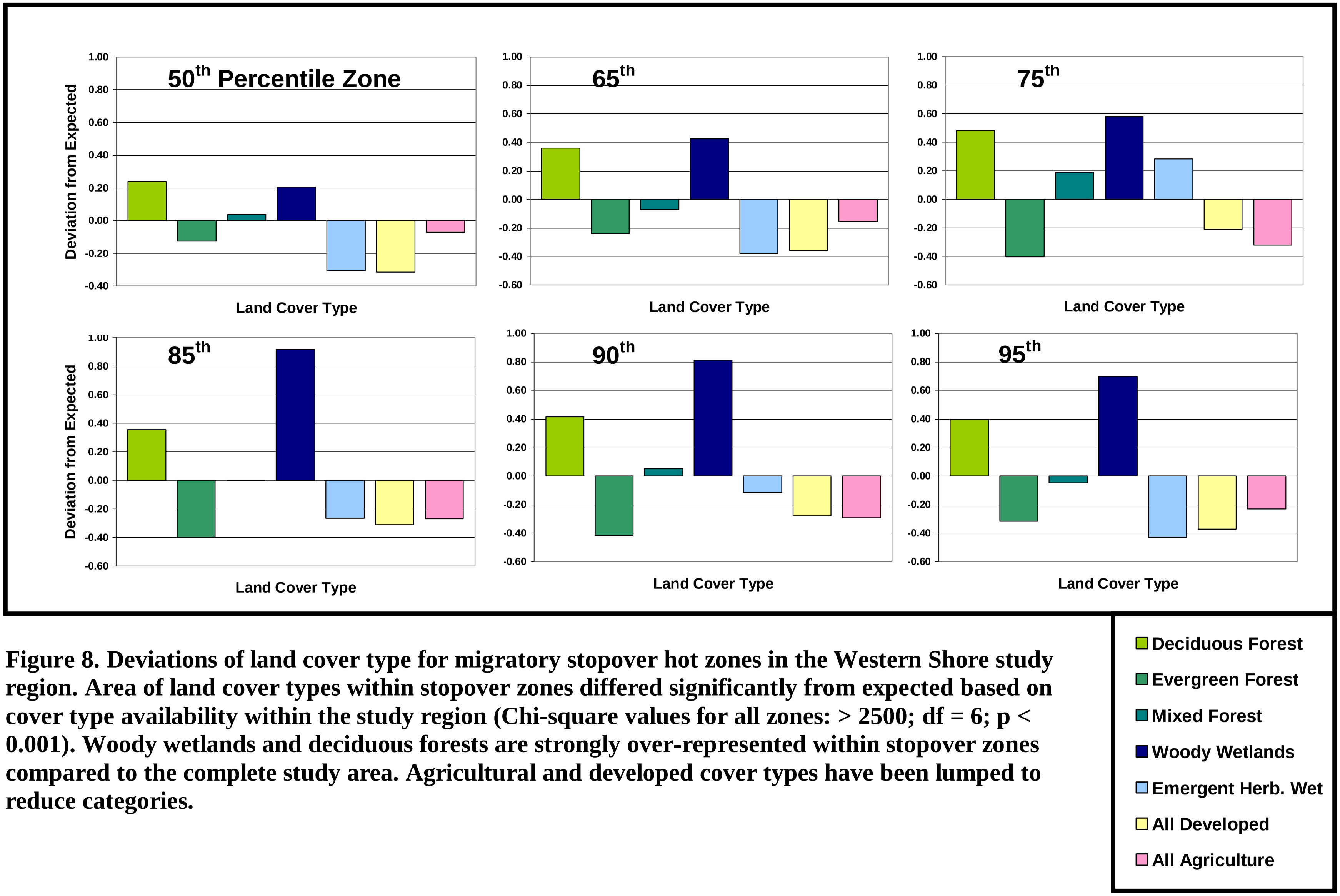


Figure 8. Deviations of land cover type for migratory stopover hot zones in the Western Shore study region. Area of land cover types within stopover zones differed significantly from expected based on cover type availability within the study region (Chi-square values for all zones: > 2500; df = 6; $p < 0.001$). Woody wetlands and deciduous forests are strongly over-represented within stopover zones compared to the complete study area. Agricultural and developed cover types have been lumped to reduce categories.

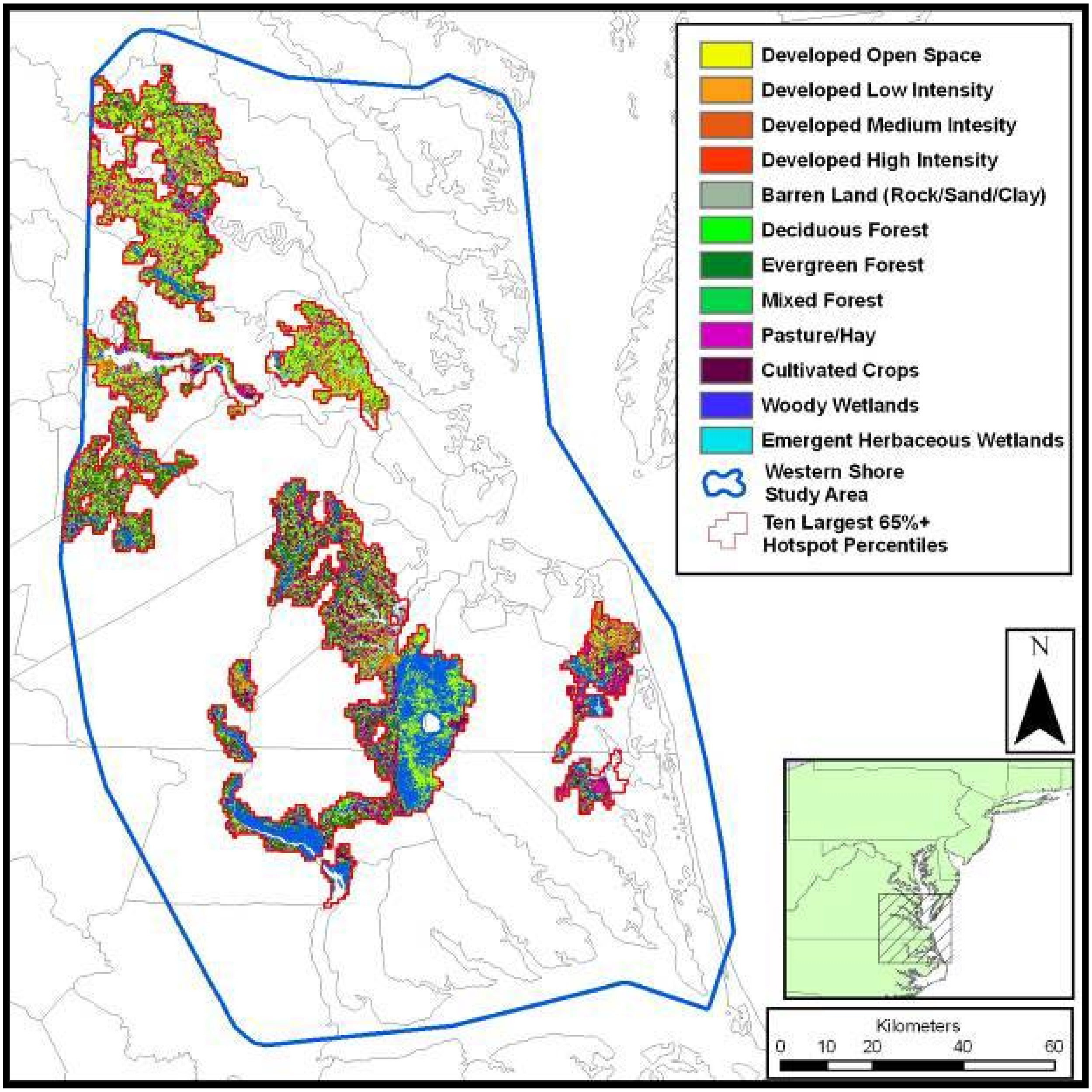


Figure 13. Land cover types within the ten largest contiguous sites in the 65th percentile stopover zone for the Western Shore study region. Southern stopover sites within the study region are characterized by extensive woody wetlands. Northern stopover sites within the region are primarily characterized by deciduous forest. Note the prevalence of developed land associated with the Franklin and Back Bay sites. Open water has been removed from land cover classification. Classification from the National Land Cover Database, USGS (Homer et al. 2004).

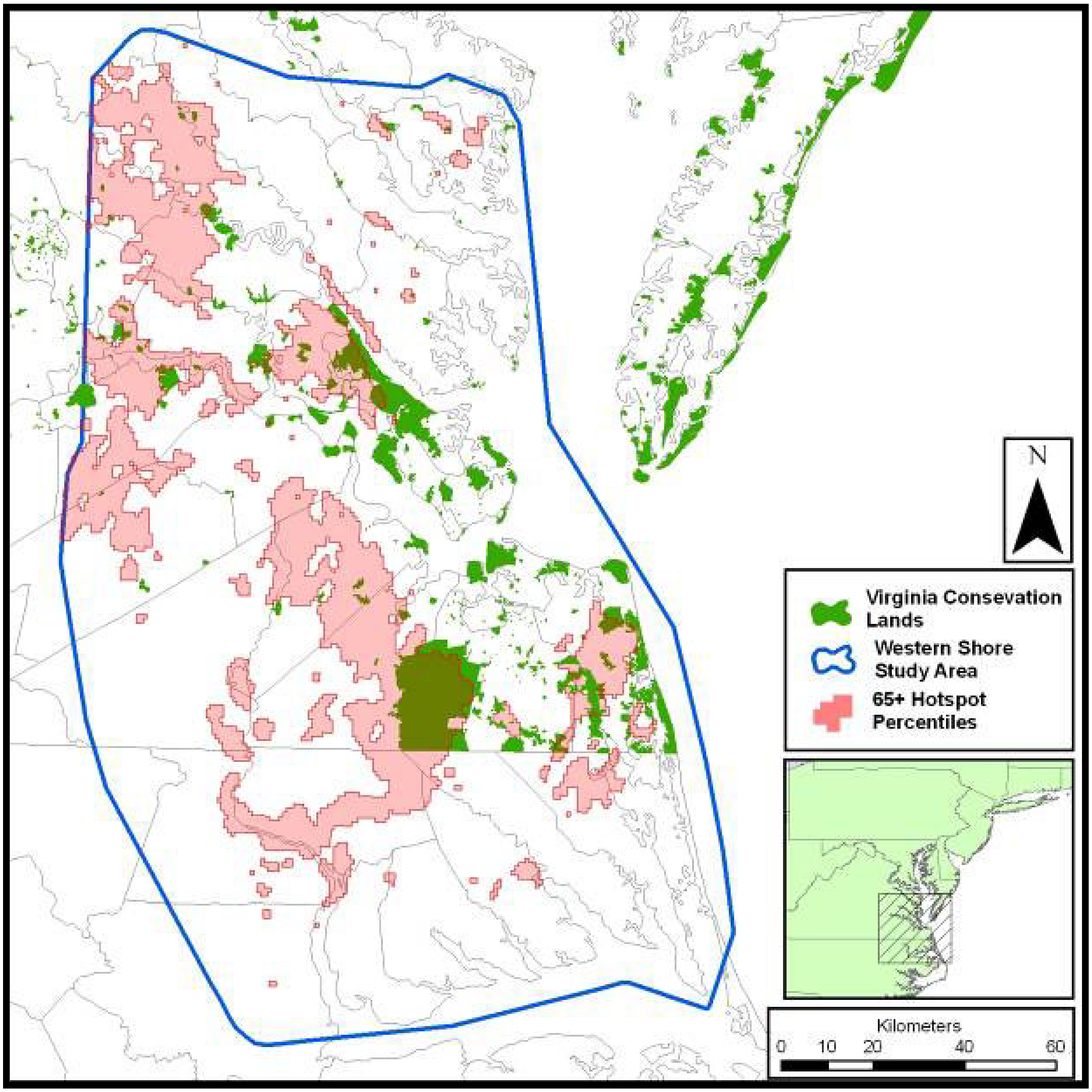


Figure 9. Spatial relationship of conservation lands in Virginia and the 65th percentile zone for migratory landbird stopover activity on the Western Shore. Conservation lands shown include those owned by conservation agencies and organizations and managed under conservation easements held by the Virginia Outdoors Foundation. Currently, only a small portion of stopover areas within Western Shore counties are protected through conservation ownership. Conservation land coverage compiled from data provided by VA Department of Conservation and Recreation, Natural Heritage Program (http://192.206.31.52/cfprog/conslands/login.cfm).

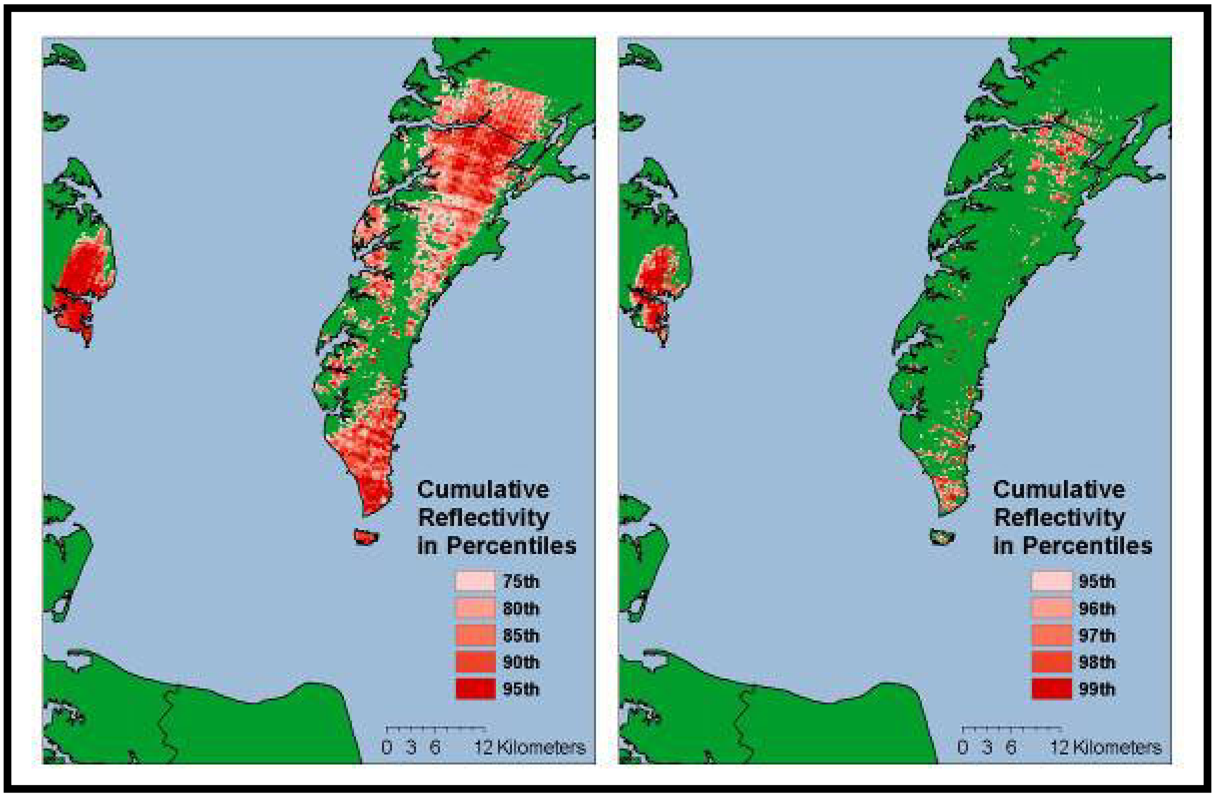


Figure 15. Preliminary analysis of fall migratory songbird exodus patterns based on 2004 NPOL radar data. Cumulative reflectivity values for the entire migration season are represented as relative values (percentiles). The figure on the left shows the exodus for the top 25th percentile and the figure on the right shows patterns for the top 5th percentile only. Areas shown may be stopover concentration sites.

	50th Percentile	65th Percentile	75th Percentile	85th Percentile	90th Percentile	95th Percentile
Developed Open Space	-0.27	-0.30	-0.31	-0.28	-0.22	-0.09
Developed Low Intensity	-0.36	-0.37	-0.43	-0.35	-0.29	-0.17
Developed Medium Intensity	-0.42	-0.40	-0.34	-0.13	-0.12	-0.06
Developed High Intensity	-0.55	-0.46	-0.24	0.11	0.04	-0.14
Barren Land (Rock/Sand/Clay)	-0.25	-0.38	-0.41	-0.44	-0.45	-0.46
Deciduous Forest	0.24	0.36	0.39	0.36	0.42	0.48
Evergreen Forest	-0.13	-0.24	-0.32	-0.40	-0.42	-0.40
Mixed Forest	0.04	-0.07	-0.05	0.00	0.05	0.19
Pasture/Hay	0.00	-0.11	-0.24	-0.36	-0.38	-0.44
Cultivated Crops	-0.13	-0.19	-0.22	-0.20	-0.22	-0.22
Woody Wetlands	0.20	0.43	0.70	0.92	0.81	0.58
Emergent Herbaceous Wetlands	-0.31	-0.38	-0.43	-0.27	-0.12	0.28

Table 1. Table 1. Land cover area deviations for stopover areas defined the top 50 percentile of cumulative target density. Area of land cover types underlying stopover hot zones differed significantly from area of available land cover types within the Western Shore region (Chi-square values for each zone level (percentile): > 1500; df = 12; p < 0.001). Table values represent the ratio defined by (observed area – expected area)/expected

	Chowan	Back Bay South	Back Bay	Williamsburg	Petersburg	Pamunkey	Lower Blackwater	James	Franklin	Dismal Complex
Developed Open Space	-1.00	-0.56	1.06	0.95	-0.86	-0.64	-0.87	0.25	2.24	-0.52
Developed Low Intensity	-1.00	-0.78	2.02	0.99	-0.90	-0.82	-0.95	-0.02	1.59	-0.70
Developed Medium Intesity	-1.00	-0.98	2.01	1.12	-0.92	-0.88	-0.98	-0.15	2.22	-0.68
Developed High Intensity	-1.00	-1.00	0.70	0.50	-0.97	-0.95	-1.00	0.86	3.97	-0.64
Barren Land (Rock/Sand/Clay)	-0.68	0.25	-0.67	-0.48	0.20	-0.36	0.48	-0.47	-0.62	-0.51
Deciduous Forest	-0.50	-0.65	-0.36	1.06	0.21	1.10	-0.30	0.54	-0.33	0.08
Evergreen Forest	-0.72	-0.03	-0.55	-0.34	0.53	-0.30	0.04	-0.19	-0.37	-0.35
Mixed Forest	-0.45	-0.98	-0.92	0.01	0.40	-0.18	0.43	-0.04	0.02	0.00
Pasture/Hay	-0.82	0.95	0.40	-0.26	-0.31	0.12	-0.64	0.27	-0.26	-0.34
Cultivated Crops	0.48	0.32	0.24	-0.69	-0.19	-0.41	-0.10	-0.41	0.38	-0.07
Woody Wetlands	3.06	-0.06	0.33	-0.56	-0.13	-0.51	1.64	-0.31	0.18	1.41
Emergent Herbaceous Wetlands	-0.18	1.03	-0.15	-0.03	-0.59	-0.69	0.01	-0.45	-0.39	-0.44

Table 2. Land cover area deviations for the ten largest Western Shore stopover sites. The area of land cover types underlying the ten largest stopover areas differed significantly from expected when compared to the available area of each land cover type within the Western Shore study region (Chi-square values for each site and all sites pooled > 1500; df = 12; p < 0.001). Table values represent the ratio defined by (observed area – expected area)/expected area.

APPENDIX A: Draft Report of Migrant Bird Ground Surveys Lower Northampton County, Virginia Fall 2003 and 2004

Fall Migratory Landbird Surveys on the Lower Delmarva Peninsula: A Summary of Ground Surveys in 2003 and 2004. (Interim Report)

Fletcher M. Smith
Barton J. Paxton
Dr. Bryan D. Watts
Center for Conservation Biology
College of William and Mary
Williamsburg, VA 23187-8795

Recommended Citation:

Smith, F. M., B. J. Paxton, Bryan D. Watts. 2004. Fall Migratory Landbird Surveys on the Lower Delmarva Peninsula: A Summary of Ground Surveys in 2003 and 2004. (Interim Report). Center for Conservation Biology Technical Report Series, CCBTR-05-88. Center for Conservation Biology, College of William and Mary, Williamsburg, VA. 54 pp.

Project Funded By:
Virginia Department of Game and Inland Fisheries
The Nature Conservancy
USGS/Patuxent WRC
USFWS
North Carolina St. University
VA Dept. of Conservation and Recreation
VA Coastal Management Program
VA Dept. of Mines, Minerals, and Energy
The Norfolk Foundation
The Mary Flagler Cary Charitable Trust

The Center for Conservation Biology is an organization dedicated to discovering innovative solutions to environmental problems that are both scientifically sound and practical within today's social context. Our philosophy has been to use a general systems approach to locate critical information needs and to plot a deliberate course of action to reach what we believe are essential information endpoints.

EXECUTIVE SUMMARY:

The Mid-Atlantic Coastal Plain plays a significant role in the life cycle of many of the most vulnerable bird species in North America. In addition to its role during the breeding and winter periods, this region is one of the most strategically located geographic areas along the entire Atlantic Flyway. Each year millions of birds pass through the region as they move between breeding areas in the northeast and winter areas within either the southeastern United States or the new world tropics. Within the mid-Atlantic Region, the lower Delmarva and Cape May peninsulas are the most significant migration bottlenecks known, concentrating large numbers of birds within relatively small land areas. Habitats within these peninsulas receive extremely high use by migrants during the fall months and are considered to have some of the highest conservation values in eastern North America. Because of its critical importance, the lower Delmarva Peninsula is the subject of land protection and habitat restoration plans being developed by the US Fish & Wildlife Service, The Nature Conservancy, and other partner agencies. It is in the Middle Atlantic Coastal Forest ecoregion (National Geographic) or the Chesapeake Bay Lowlands ecoregion (The Nature Conservancy).

This landcover analysis project resulted in the digitization of 2,147 forest patches totaling 13,836 ha from the 1994 imagery and 2,581 patches totaling 13,499 hectares from the 2002 imagery. For analysis purposes only patches with a total area greater than 0.4 ha were included. This resulted in 1,099 patches totaling 13,667 ha from 1994 imagery and 1,209 patches totaling 13,287 ha from the 2002 imagery. Between 1994 and 2002 a gross loss of 821 ha of forested habitat was observed. During this same time period a gross gain of 289 ha was also observed. When combined, the resulting change was a 532 ha (or 3.9%) loss in forested habitat. The data also show a shift toward a greater number of smaller patches.

A total of 10,716 birds were detected in the 2003 fall migration study and a total of 19,453 were detected in the 2004 fall migration study. A total of 2,424 point counts were conducted in 2003, and a total of 5,706 were conducted in 2004. All birds were categorized by their migratory status. Only neotropical and temperate migrants are used for analysis. A total of 2,424 point counts were conducted in the fall of 2003. A total of 10,716 birds were detected, with 3,093 of those being neotropical migrants and 4,161 being temperate migrants. 61 species of neotropical migratory birds were detected in 2003, and 32 species of temperate migrants were detected. A total of 5,706 point counts were conducted in 2004, with 19,453 total birds detected. The total number of neotropical migrants detected was 4,572 and the total number of temperate migrants detected was 7,233. The total number of neotropical migratory species detected in 2004 was 68. A total of 44 temperate migrant species were detected in 2004.

BACKGROUND:

The Mid-Atlantic Coastal Plain plays a significant role in the life cycle of many of the most vulnerable bird species in North America. In addition to its role during the breeding and winter periods, this region is one of the most strategically located geographic areas along the entire Atlantic Flyway. Each year millions of birds pass through the region as they move between breeding areas in the northeast and winter areas within either the southeastern United

States or the new world tropics. Within the mid-Atlantic Region, the lower Delmarva and Cape May peninsulas are the most significant migration bottlenecks known, concentrating large numbers of birds within relatively small land areas. Habitats within these peninsulas receive extremely high use by migrants during the fall months and are considered to have some of the highest conservation values in eastern North America. Because of its critical importance, the lower Delmarva Peninsula is the subject of land protection and habitat restoration plans being developed by the US Fish & Wildlife Service, The Nature Conservancy, and other partner agencies. It is in the Middle Atlantic Coastal Forest ecoregion (National Geographic) or the Chesapeake Bay Lowlands ecoregion (The Nature Conservancy).

Along the lower Delmarva Peninsula, habitats close to the southern tip appear to have the greatest significance to migrants. Recent broad-scale investigations have documented a steep density gradient of migrants extending south to north within the lower 20 km (Watts and Mabey, 1994). Migrants “fall out” in the early morning hours as they reach the mouth of the Chesapeake Bay and become highly concentrated within available habitat. Within the highest concentration areas vegetation density appears to be the best predictor of migrant distribution (Watts and Mabey). Foraging studies have demonstrated that forest type has a significant influence on energy intake (Watts and Wilson). An investigation completed during the fall of 2001 has documented significant levels of resource depression within the concentration area suggesting that habitat availability/quality may directly influence the condition of migrants during stopover periods (Watts and Paxton).

The Eastern Shore of Virginia has remained a relatively isolated rural agricultural community because of limited access. Most of the upland portion of Northampton County (54%) is in agricultural use with forest covering 38%. Forest and shrub is restricted to riparian corridors along creeks, or in small fragmented patches associated with poorly drained soils, or in areas otherwise not farmed. Because of increasing development pressure, many patches of forest habitat within the lower Delmarva Peninsula area are in eminent danger of becoming lost or degraded within the near future, resulting in a cumulative loss of key habitats. Loss of habitat at this focal point may have far-reaching consequences as most of the neotropical birds that breed throughout northeastern North America pass through this area while on fall migration to the Caribbean and Latin America. A recently completed impact study focused on the Chesapeake Bay Bridge-Tunnel toll reduction, projected that most of the residential and commercial growth triggered would occur within in lower Northampton County with approximately 45% of the land permanently lost to development in the near future. Development pressure will be greatest within the bayside corridor that has been designated as the most critical stopover habitat within the concentration area. Subdivision of bayside tracts is now occurring at a rapid rate as land prices have escalated since the toll was reduced in March 2002.

This project, a partnership effort between The Nature Conservancy, North Carolina State University, and the Center for Conservation Biology at the College of William & Mary, proposes to evaluate the quality and quantity of existing stopover habitats for neotropical migratory birds on the lower Delmarva peninsula. Specifically, we propose to inventory and characterize through a full GIS analysis and ground sampling the existing stopover habitats/forest patches in the land protection plan corridors on both sides of the lower peninsula as proposed by both the US Fish & Wildlife Service and The Nature Conservancy. Using existing data on bird use and new data generated by the ground studies and concurrent Nexrad/doppler radar studies of significant entrance/exit locations, we will classify the habitats/forest patches according to use (distribution, abundance, and consistency over time) by neotropical migratory birds

OBJECTIVES:

The overriding objective of this project was to provide information products that will improve the efficacy of conservation programs for neotropical migratory birds within the proposed protection plan corridors on the lower Delmarva. Sub-objectives include: (1) the completion of a status assessment of habitat availability/quality within the protection plan corridors that may be used as a "benchmark" for future comparisons, (2) prioritization of land parcels within the corridors according to their significance to neotropical migratory birds, and (3) design of usable forest management practices that enhance habitat quality for neotropical migratory birds. The results will enable the US Fish & Wildlife Service, The Nature Conservancy, and other partner agencies to accomplish more effective conservation for neotropical birds on the lower Delmarva Peninsula.

This report looks at data collected during the 2003 and 2004 fall migration seasons. This data is part of the larger study to evaluate the quality and quantity of existing stopover habitats for neotropical migratory birds on the lower Delmarva Peninsula. Analyses are continuing on these data in relation to patch size, habitat quality and position on the peninsula. A final report addressing all factors mentioned will be produced in mid-summer of 2005 and will be distributed to the project partners upon completion.

METHODS:

Migratory Bird Surveys and Study Area

All point count surveys were confined to the lower 20 kilometers of Northampton County, Virginia (see figure 1). A total of 32 forest patches were surveyed for birds in both 2003 and 2004. Two forest patches were added in 2004 and two were dropped from 2003 due to damage caused by Hurricane Isabel. A total of 192 points were set up within the 32 forest patches. All points were replicated both years except for the two new forest patches. Point counts were subdivided into either bayside (within close proximity to the bay) or interior (within close proximity to the mid-line) (Figure 1). There were 16 bayside and 16 interior forest patches. All bayside patches were surveyed in the same day and all interior patches were surveyed in the same day, with surveys alternating between the two. The 2003 fall migration surveys were conducted between 9 September 2003 and 21 October 2003. The 2004 fall migration surveys were conducted between 15 August 2004 and 15 November 2004. Surveys were broken up into survey rounds, with a survey round being 4 surveys conducted within a 6 day period. Technicians switched survey assignments each survey day to avoid observer bias. Surveys were conducted between 0.5 hours after sunrise and 4.5 hours after sunrise. For detections of migratory songbirds, a 30m fixed radius point count methodology was used both years. This entailed identifying and tallying all birds detected within the point count circle during each 5 minute point count. Birds were recorded into field notebooks and entered into a database.

Analyses being performed will compare overall bird use and differences in neotropical and temperate migrant abundance between midline and bayside patches. This data when combined with other data (i.e. banding summaries) and habitat characteristics will be used to evaluate the quality and quantity of existing stopover habitats.

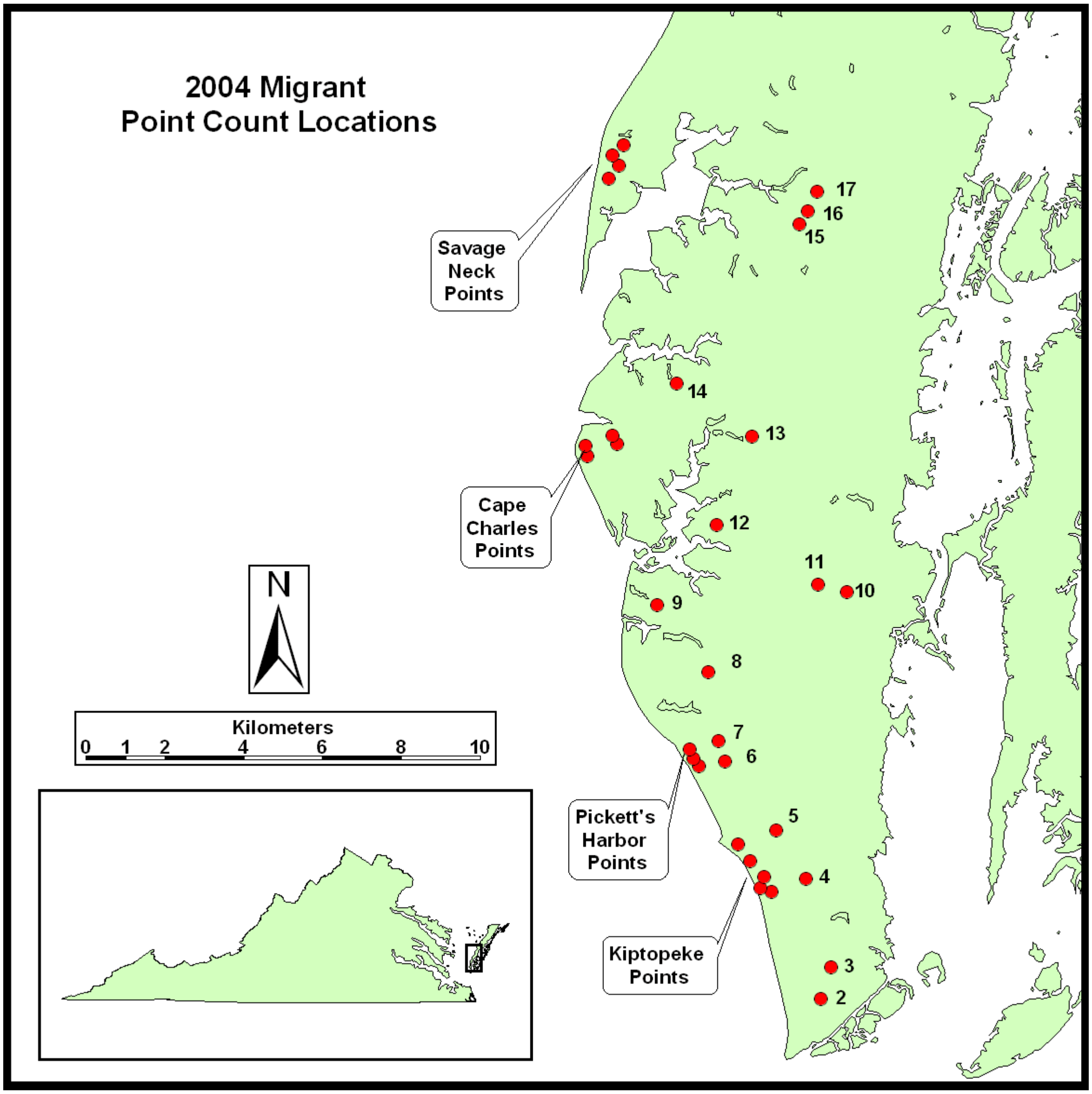


Figure 1. Overview of all points surveyed in the 2004 fall migration study. Most of these points were also surveyed during the 2003 fall migration study (two forest patches were lost to Hurricane Isabel damage).

HABITAT MEASURMENTS:

Overview:

Vegetation was measured within three subplots from each 30m radius point count circle. The center of each subplot was 17m from the point center along 120° bearings (initial bearing random) and consists of a 5m radius circle nested within an 11.4m radius circle (See Figure 2).

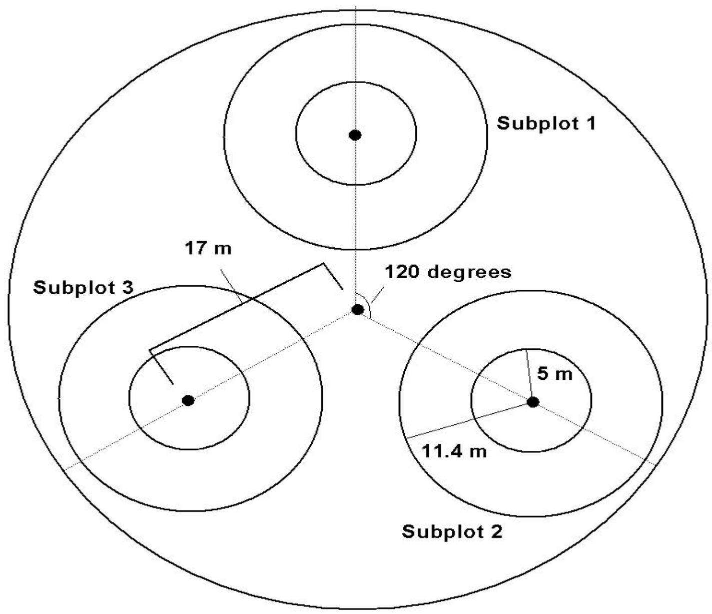


Figure 2. Diagram of Vegetation Plot Layout for 11.4m and 5m radius circles.

Vegetation Measurements Collected Within 11.4 radius circle:

All trees within the 11.4 m radius circle with a diameter at breast height (DBH) greater than 8cm were counted and identified to the species level. These trees were placed into three DBH categories: 8-23 cm, 23-38cm, and greater than 38cm. Snags were included as a species. Trees exactly on the edge of the radius were alternately included and excluded in the data. The mean canopy height was measured with a rangefinder and a clinometer in each 11.4m circle. Four readings were taken on a spherical densitometer at the subplot center and averaged to determine canopy coverage.

The two closest trees from each DBH category were identified to species and the distances to those trees from the center of the subplot were recorded. The heights of the two closest trees from each DBH category were also recorded.

Vegetation Measurements Collected Within 5m radius circle:

Within the 5m radius circle visual estimates were made to quantify the percentage of ground cover by bare ground, leaf litter, grass, and forbs. The depth of leaf litter was measured to the nearest cm, as was if an organic layer was present or if the ground consisted primarily of sand, rock, or clay. All woody stems less than 8cm and greater than .5m tall were identified, counted, and placed into two size classes: less than 2.5cm, and 2.5-8cm. The numbers of vertical stems above 10cm were also counted. Any large non-woody stems (ie: phragmites, poke berry) that added to the structure of the plot were counted. The percentages of shrubs that were or would be bearing fruit were estimated.

Vegetation Measurements Collected With a Robel Pole:

Vegetation density was measured with a 4m Robel pole along four 90° bearings (initial bearing random)(see Figure 3). The first measurement was taken six meters from the center of the circle along the chosen bearing, with three subsequent Robel measurements taken at 6m intervals along this bearing. The measurements consisted of holding the pole vertically and counting the number of times vegetation came within .1m of the pole at .1m increments, with subtotals at each .5m increment. The dominant species at each .5m increment was recorded, as was the percentage of fruit bearing stems.

Forest patches were visually identified using 1994 Virginia DOQQ imagery and 2002 Virginia base map imagery, and digitized using ArcView GIS software. During digitizing, patches were separated by roads or 10 meters of treeless land. Linear patches of forest less than 10 m in width were not included unless they connected larger forest patches. For analysis purposes, only forest patches with an area greater than 0.4 ha were included. Analysis of individual patches included area, perimeter, patch center coordinates, ID and distance to the nearest 5 patches, forest composition, forest density, and patch age. Forest composition was determined by a combination of image analysis and area measurements based on visual cover identification. Forest density was determined visually and by actual measurement of stem density. Forest age was determined by visual estimation and actual measurement of tree crown diameter.

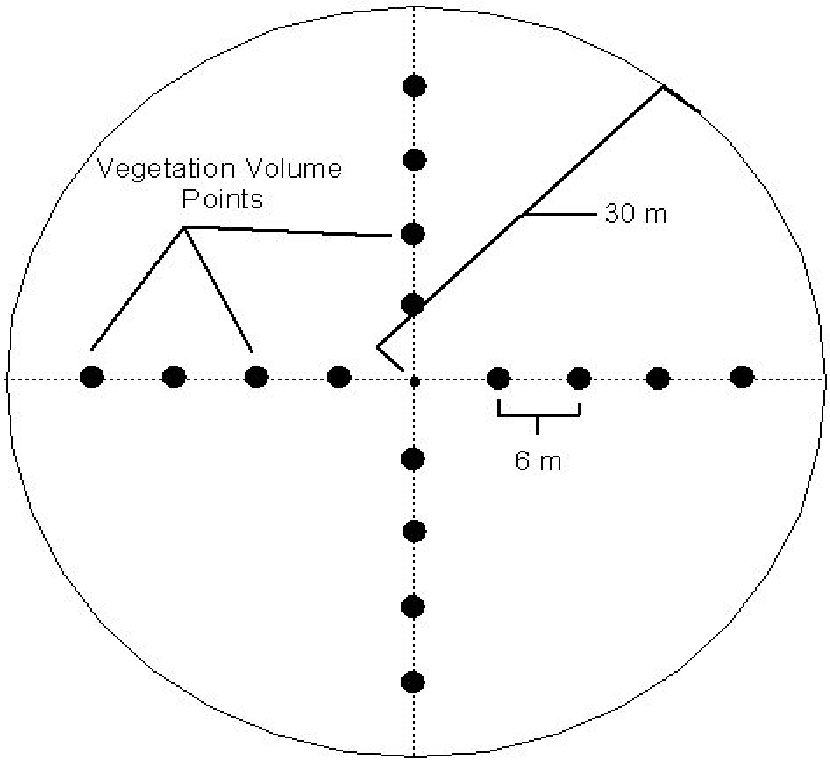


Figure 3. Diagram of Vegetation Plot Layout for Robel Pole Measurements.

Habitat Analysis Results:

During the production of the forest patch layer for the lower 20 kilometers, and with communications with landowners, the direct effect of development pressure became apparent. Review of Northampton County tax maps revealed the disturbing trend of large blocks of land being subdivided into multiple smaller blocks, as well as increased ownership by land development companies. Review of aerial photography showed that many forest patches had been harvested, and through conversations with landowners, it became apparent that owners were harvesting timber prior to the sale of their land.

The focus of this project was to produce an assessment of forest habitat within the northern 29 km of Northampton County. This assessment was combined with the assessment of the lower 20 km to assist in the identification of significant neotropical migrant stopover habitat and serve as a benchmark for future comparisons to measure the effectiveness of conservation efforts within the lower peninsula. After digitizing the patches from the 2002 Virginia base map imagery, it became apparent that the digitization of forest patches from the 1994 Virginia DOQQs was necessary to assess forest loss over the past 8 years, and thus was included in this project.

This project resulted in the digitization of 2,147 forest patches totaling 13,836 ha from the 1994 imagery and 2,581 patches totaling 13,499 hectares from the 2002 imagery. For analysis purposes only patches with a total area greater than 0.4 ha were included. This resulted in 1,099 patches totaling 13,667 ha from 1994 imagery and 1,209 patches totaling 13,287 ha from the 2002 imagery. Between 1994 and 2002 a gross loss of 821 ha of forested habitat was observed. During this same time period a gross gain of 289 ha was also observed. When combined, the resulting change was a 532 ha (or 3.9%) loss in forested habitat. The data also show a shift toward a greater number of smaller patches.

Forest patch level analysis is ongoing and will be included in the final report.

Point Count Survey Results

A total of 10,716 birds were detected in 2003 and a total of 19,453 were detected in 2004 (see appendix 2 for a list of all species detected in both years). A total of 2,424 point counts were conducted in 2003, and a total of 5,706 were conducted in 2004. All birds were categorized by their migratory status. Only neotropical and temperate migrants are used for analysis. A total of 3,093 neotropical migrants comprising 61 species and 4,161 temperate migrants comprising 32 species were detected in 2003. The total number of neotropical migrants detected in 2004 was 4,572 and the total number of temperate migrants detected in 2004 was 7,233. The total number of neotropical migratory species detected in 2004 was 68. A total of 44 temperate migrant species were detected in 2004 (see appendix 3 and 4 for a list of species detected by survey round).

The majority of birds detected on the bayside patches were migratory birds. The majority of birds detected on the midline patches were resident birds (Table 1)

Table 1. Comparison of detections between patch locations.

	Bay Patches	**Midline Patches**
Resident Species	4,501 (48%)	4,875 (52%)
Migrant Species	11,291 (54.7%)	9,345 (45.3%)
Total	15,792 (52.6%)	14,220 (47.4%)

Seasonal patterns of detection will be examined in detail in the final report. The temporal distribution of migrant birds is shown in figures 4 and 5.

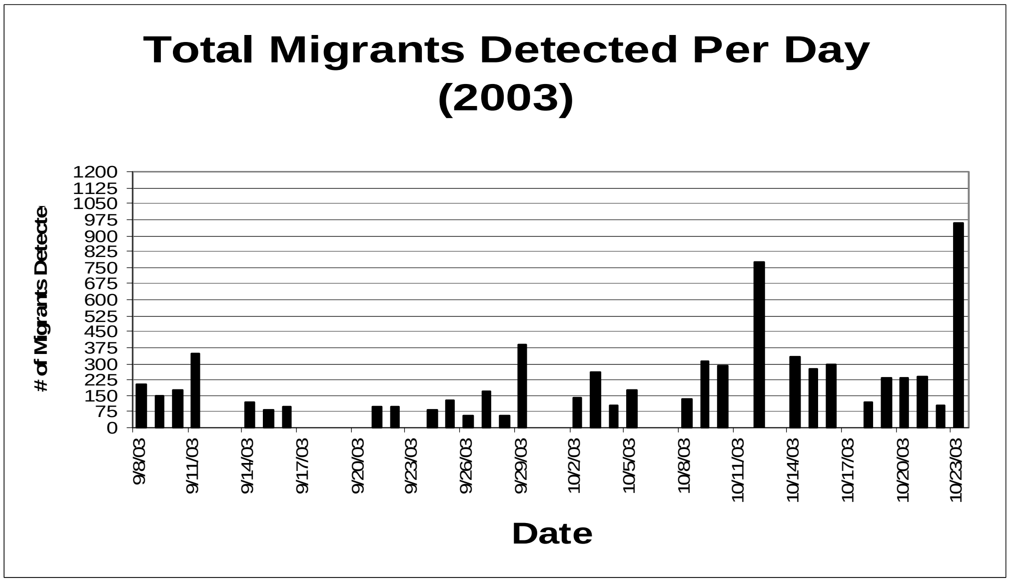


Figure 4. Temporal distribution of migratory birds detected for 2003 fall migration study.

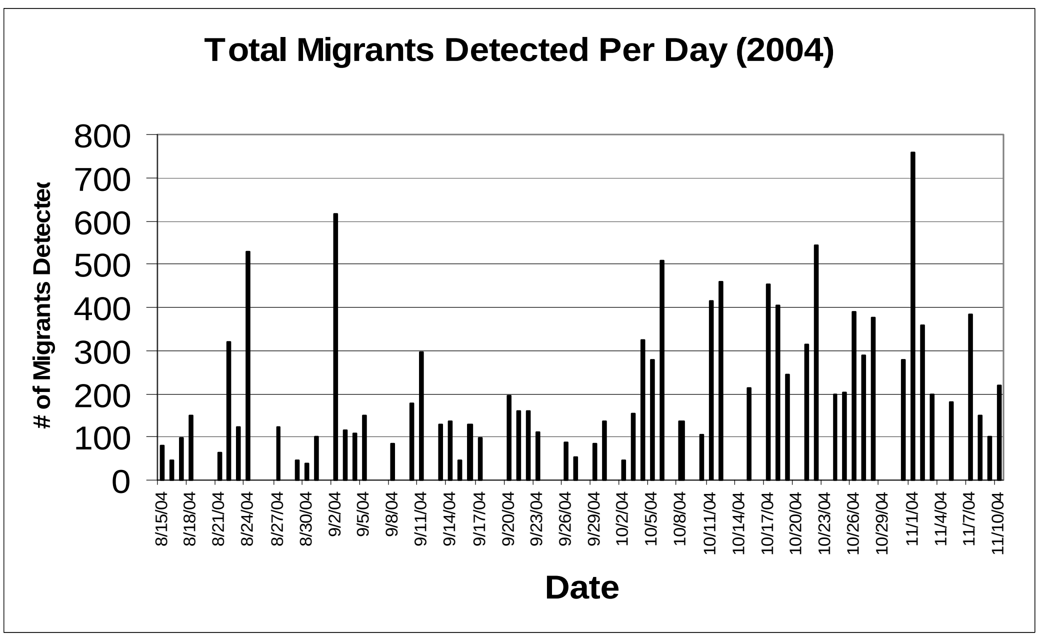


Figure 5. Temporal distribution of migratory birds detected for 2004 fall migration study.

DISCUSSION:

Preliminary analyses suggest that forest patches along the bayside of the peninsula are used by a greater number of migrant birds than midline patches. This may be due to a combination of factors including a reverse migration that has been observed when migrants reach the tip of the peninsula and, being reluctant to cross the bay, move northward up the peninsula along the bay shoreline. The migrant that exhibit this reverse migration typically will wait for more favorable weather conditions to make the bay crossing. Whether or not bayside patches provide a better quality and quantity of stopover habitat for neotropical migratory birds has yet to be determined, and is the focus of the larger study of which these bird surveys were a component. Multivariate analysis of neotropical bird use of Northampton County forest patches is ongoing and will be included in the final report.

Preliminary data also suggests that migratory bird species are using the same strata levels as in study conducted in 1992 and 1993 (Watts and Mabey, 1994)(see appendix 1).

ACKNOWLEDGMENTS:

This project would not have been possible without the efforts of many people; Ruth Boettcher at the Virginia Department of Game and Inland Fisheries, Laura McKay at the Virginia Department of Environmental Quality Virginia Coastal Program, Steve Parker, Dave Harris, and Barry Truitt and the whole staff of The Nature Conservancy, Sue Rice, Pam Denmon, and the staff of the Eastern Shore National Wildlife Refuge, Dot Field of Department of Conservation and Recreation, Sam Sweeney and the entire staff of Kiptopeke State Park, many private landowners that granted us permission to do point counts on their land (including Mary Peacock, George Savage, and Pat Hand and family), Deanna Dawson at U.S. Geological Survey in Patuxent, Bay Creek and Tom Saunders, Oral Lambert, and many others. We appreciate the dedicated efforts of Caroline Causey, Pierre Goulet, Joshua Nemeth, Daniel Rauch, Nicholas VanLanen, and Michelle Wilcox in conducting vegetation surveys. Funds from the U.S. Geological Survey allowed for the assessment of the lower 20 km of the County. Lydia Whitaker, Carlton Adams, Renee Peace, Anne Womack, Gloria Sciole, Mark Roberts, and Cheryl Pope provided important administrative support from the College of William and Mary.

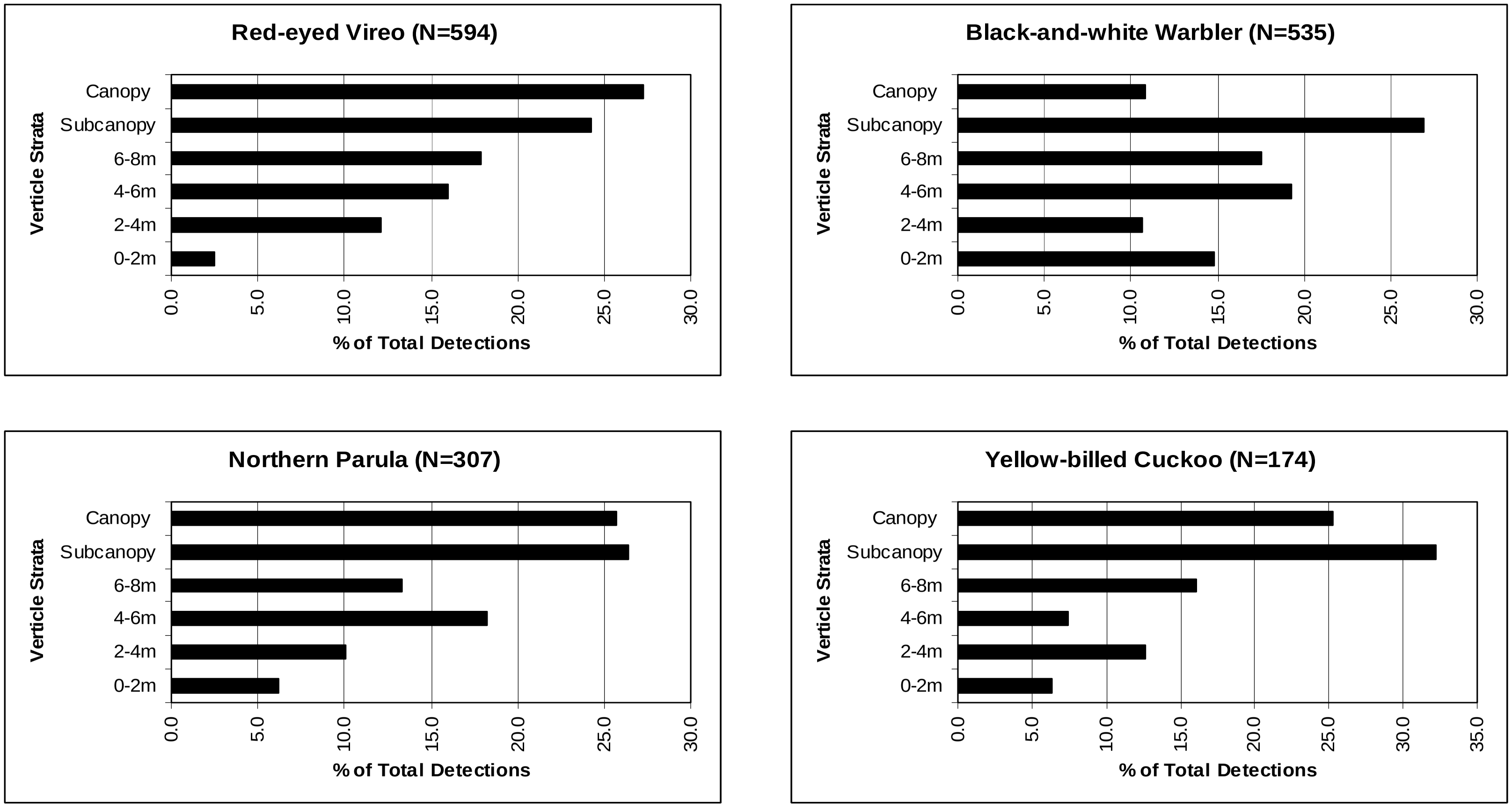
LITERATURE CITED:

Paxton,B.J. and B.D. Watts. 2001. Fall Stop-over Ecology of Neotropical Migrants: Are Inner or Outer Coastal Habitats Energy Sources for Migrants. Center for Conservation Biology Technical Report Series CCBTR-01-10. Center for Conservation Biology, College of William and Mary, Williamsburg, VA. 46 pp.

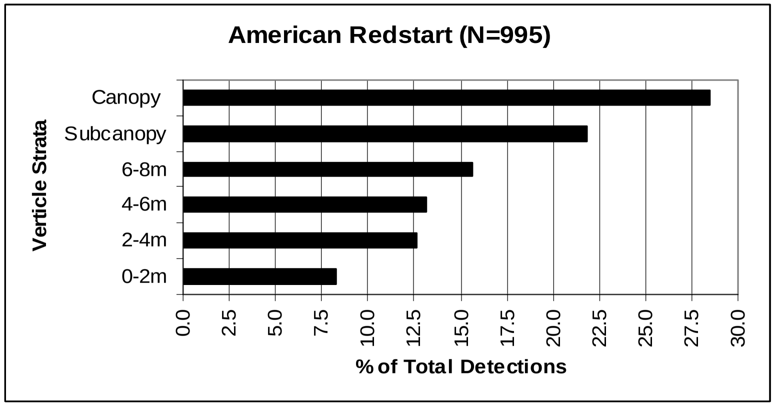
Watts, B.D. and S.E. Mabey, 1994. Migratory Landbirds of the Lower Delmarva: Habitat Selection and Geographic Distribution. Center for Conservation Biology Technical Report Series. Center for Conservation Biology, College of William and Mary, Williamsburg, VA. 78 pp.

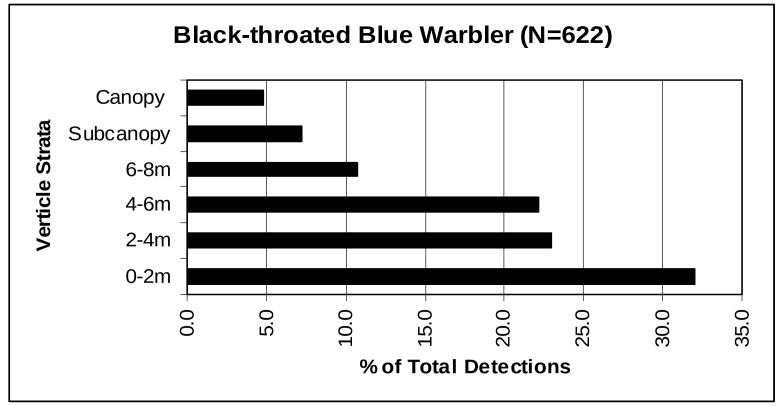
Watts, B.D. and M.D. Wilson. 1998. Diversity and Abundance of Migratory Landbirds on Little Creek Naval Amphibious Base. Center for Conservation Biology Technical Report Series CCBTR-98-03. Center for Conservation Biology, College of William and Mary, Williamsburg, VA. 62 pp.

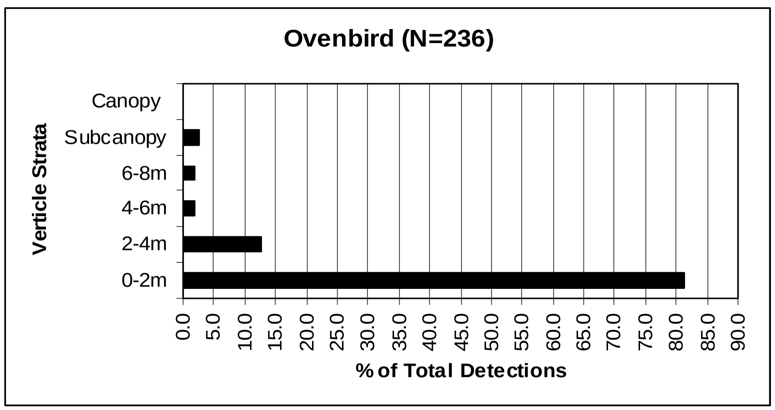
Appendix 1. Use of vertical strata by selected **neotropical migratory birds**. Patterns reflect data from the 2003 and 2004 fall migration studies.



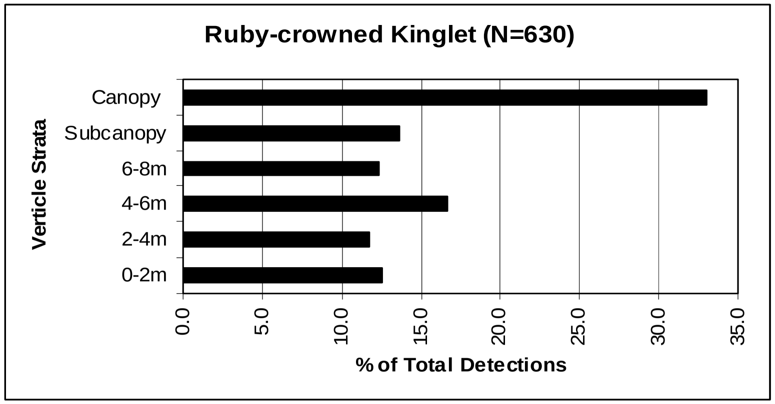
Appendix 1 (continued). Use of vertical strata by selected **neotropical migratory birds**. Patterns reflect data from the 2003 and 2004 fall migration studies.

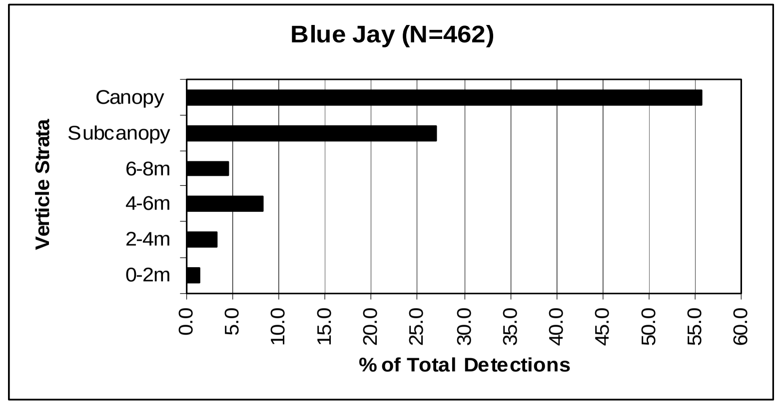


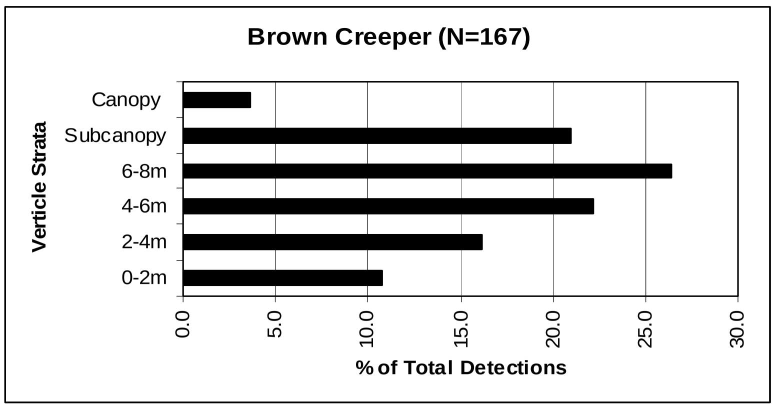


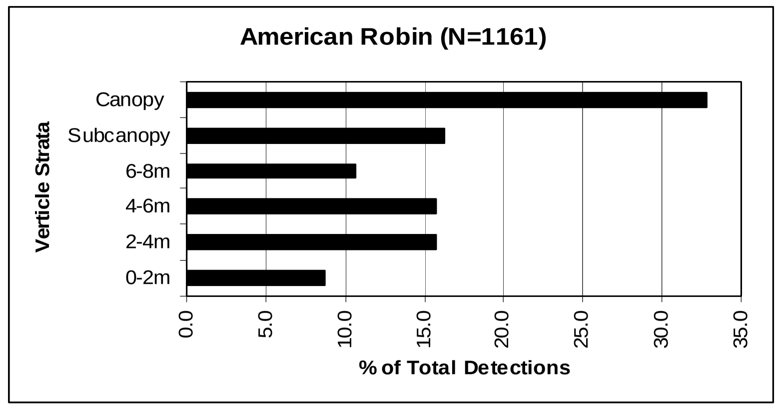


Appendix 1 (continued). Use of vertical strata by selected **temperate migrant birds**. Patterns reflect data from the 2003 and 2004 fall migration studies.

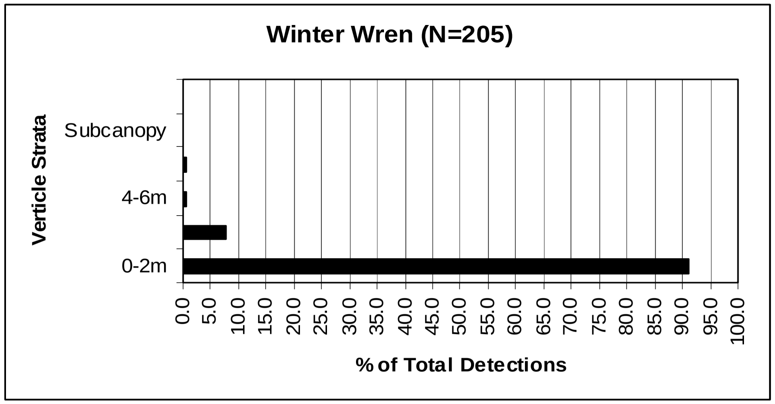


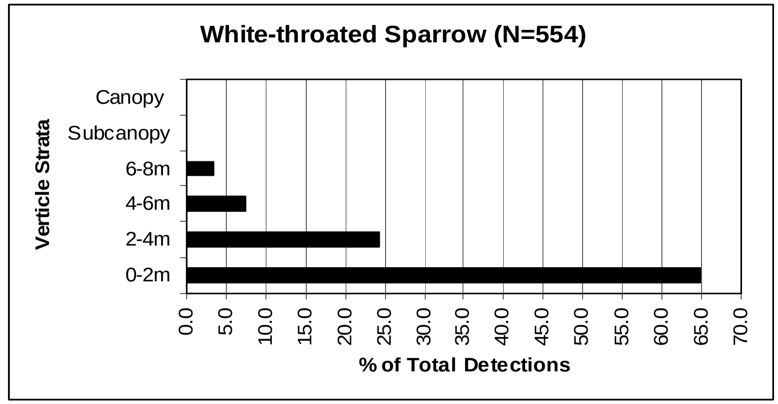


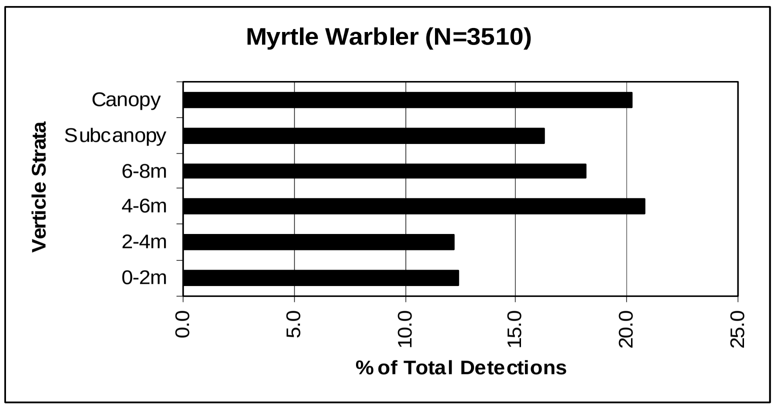


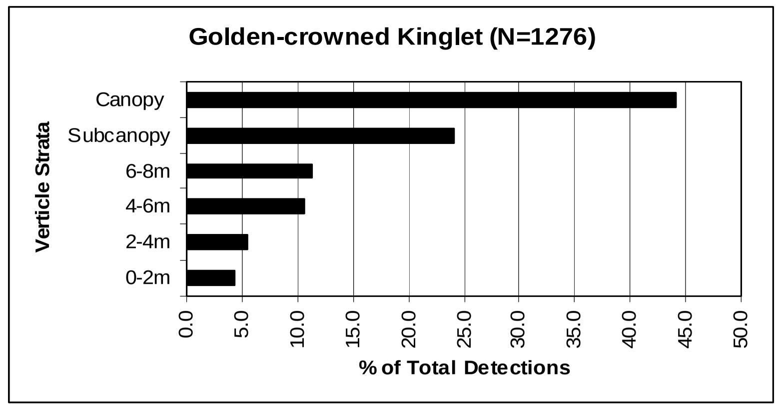


Appendix 1 (continued). Use of vertical strata by selected **temperate migrant birds**. Patterns reflect data from the 2003 and 2004 fall migration studies.









Appendix 2. List of species detected in 2003 and 2004 fall migration studies with common name, scientific name, migratory status, and year detected.

Common Name	Genus	Species	Migratory Status	2003	2004
Yellow-bellied Flycatcher	*Empidonax*	*flaviventris*	Neotropical Migrant	x	x
Acadian Flycatcher	*Empidonax*	*virescens*	Neotropical Migrant	x	x
Traill's Flycatcher	*Empidonax*		Neotropical Migrant	x	x
Least Flycatcher	*Empidonax*	*minimus*	Neotropical Migrant		x
Blue Jay	*Cyanocitta*	*cristata*	Temperate Migrant	x	x
American Crow	*Corvus*	*brachyrhynchos*	Resident	x	x
Fish Crow	*Corvus*	*ossifragus*	Resident	x	
European Starling	*Sturnus*	*vulgaris*	Resident		x
Brown-headed Cowbird	*Molothrus*	*ater*	Resident		x
Red-winged Blackbird	*Agelaius*	*phoeniceus*	Resident		x
Orchard Oriole	*Icterus*	*spurius*	Neotropical Migrant	x	x
Baltimore Oriole	*Icterus*	*galbula*	Neotropical Migrant	x	x
Rusty Blackbird	*Euphagus*	*carolinus*	Temperate Migrant		x
Common Grackle	*Quiscalus*	*quiscula*	Resident	x	x
Purple Finch	*Carpodacus*	*purpureus*	Temperate Migrant		x
House Finch	*Carpodacus*	*mexicanus*	Resident		x
American Goldfinch	*Carduelis*	*tristis*	Temperate Migrant	x	x
Pine Siskin	*Carduelis*	*pinus*	Temperate Migrant		x
Vesper Sparrow	*Pooecetes*	*gramineus*	Temperate Migrant		x
Savannah Sparrow	*Passerculus*	*sandwichensis*	Temperate Migrant		x
White-crowned Sparrow	*Zonotrichia*	*leucophrys*	Temperate Migrant		x
White-throated Sparrow	*Zonotrichia*	*albicollis*	Temperate Migrant	x	x
Chipping Sparrow	*Spizella*	*passerina*	Temperate Migrant	x	x
Field Sparrow	*Spizella*	*pusilla*	Temperate Migrant	x	x
Slate-colored Junco	*Junco*	*hyemalis*	Temperate Migrant	x	x
Song Sparrow	*Melospiza*	*melodia*	Temperate Migrant	x	x
Lincoln's Sparrow	*Melospiza*	*lincolnii*	Temperate Migrant		x
Swamp Sparrow	*Melospiza*	*georgiana*	Temperate Migrant	x	x
Eastern Towhee	*Pipilo*	*erythrophthalmus*	Temperate Migrant	x	x
Northern Cardinal	*Cardinalis*	*cardinalis*	Resident	x	x
Rose-breasted Grosbeak	*Pheucticus*	*ludovicianus*	Neotropical Migrant	x	x
Blue Grosbeak	*Passerina*	*caerulea*	Neotropical Migrant	x	x
Indigo Bunting	*Passerina*	*cyanea*	Neotropical Migrant	x	x
Scarlet Tanager	*Piranga*	*olivacea*	Neotropical Migrant	x	x
Summer Tanager	*Piranga*	*rubra*	Neotropical Migrant	x	x
Cedar Waxwing	*Bombycilla*	*cedrorum*	Temperate Migrant	x	x
Red-eyed Vireo	*Vireo*	*olivaceus*	Neotropical Migrant	x	x
Philadelphia Vireo	*Vireo*	*philadelphicus*	Neotropical Migrant	x	x
Warbling Vireo	*Vireo*	*gilvus*	Neotropical Migrant	x	x
Yellow-throated Vireo	*Vireo*	*flavifrons*	Neotropical Migrant	x	x
Blue-headed Vireo	*Vireo*	*solitarius*	Neotropical Migrant		x
White-eyed Vireo	*Vireo*	*griseus*	Neotropical Migrant	x	x
Black-and-White Warbler	*Mniotilta*	*varia*	Neotropical Migrant	x	x

Appendix 2 (continued). List of species detected in 2003 and 2004 fall migration studies with common name, scientific name, migratory status, and year detected.

Common Name	Genus	Species	Migratory Status	2003	2004
Prothonotary Warbler	*Protonotaria*	*citrea*	Neotropical Migrant	x	x
Worm-eating Warbler	*Helmitheros*	*vermivorum*	Neotropical Migrant	x	x
Blue-winged Warbler	*Vermivora*	*pinus*	Neotropical Migrant	x	x
Brewster's Warbler	*Vermivora*		Neotropical Migrant		x
Golden-winged Warbler	*Vermivora*	*chrysoptera*	Neotropical Migrant		x
Nashville Warbler	*Vermivora*	*ruficapilla*	Neotropical Migrant	x	x
Orange-crowned Warbler	*Vermivora*	*celata*	Neotropical Migrant	x	
Tennessee Warbler	*Vermivora*	*peregrina*	Neotropical Migrant	x	x
Northern Parula	*Parula*	*americana*	Neotropical Migrant	x	x
Cape May Warbler	*Dendroica*	*tigrina*	Neotropical Migrant	x	x
Yellow Warbler	*Dendroica*	*petechia*	Neotropical Migrant	x	x
Black-throated Blue Warbler	*Dendroica*	*caerulescens*	Neotropical Migrant	x	x
Myrtle Warbler	*Dendroica*	*coronata*	Temperate Migrant	x	x
Magnolia Warbler	*Dendroica*	*magnolia*	Neotropical Migrant	x	x
Cerulean Warbler	*Dendroica*	*cerulea*	Neotropical Migrant	x	x
Chestnut-sided Warbler	*Dendroica*	*pensylvanica*	Neotropical Migrant	x	x
Bay-breasted Warbler	*Dendroica*	*castanea*	Neotropical Migrant	x	x
Blackpoll Warbler	*Dendroica*	*striata*	Neotropical Migrant	x	x
Blackburnian Warbler	*Dendroica*	*fusca*	Neotropical Migrant		x
Yellow-throated Warbler	*Dendroica*	*dominica*	Neotropical Migrant		x
Black-throated Green Warbler	*Dendroica*	*virens*	Neotropical Migrant	x	x
Pine Warbler	*Dendroica*	*pinus*	Temperate Migrant	x	x
Western Palm Warbler	*Dendroica*	*palmarum*	Neotropical Migrant	x	x
Prairie Warbler	*Dendroica*	*discolor*	Neotropical Migrant	x	x
Ovenbird	*Seiurus*	*aurocapilla*	Neotropical Migrant	x	x
Northern Waterthrush	*Seiurus*	*noveboracensis*	Neotropical Migrant	x	x
Louisiana Waterthrush	*Seiurus*	*motacilla*	Neotropical Migrant		x
Kentucky Warbler	*Oporornis*	*formosus*	Neotropical Migrant		x
Connecticut Warbler	*Oporornis*	*agilis*	Neotropical Migrant	x	
Mourning Warbler	*Oporornis*	*philadelphia*	Neotropical Migrant		x
Common Yellowthroat	*Geothlypis*	*trichas*	Neotropical Migrant	x	x
Yellow-breasted Chat	*Icteria*	*virens*	Neotropical Migrant	x	x
Hooded Warbler	*Wilsonia*	*citrina*	Neotropical Migrant	x	x
Wilson's Warbler	*Wilsonia*	*pusilla*	Neotropical Migrant	x	
Canada Warbler	*Wilsonia*	*canadensis*	Neotropical Migrant		x
American Redstart	*Setophaga*	*ruticilla*	Neotropical Migrant	x	x
Northern Mockingbird	*Mimus*	*polyglottos*	Resident	x	x
Gray Catbird	*Dumetella*	*carolinensis*	Neotropical Migrant	x	x
Brown Thrasher	*Toxostoma*	*rufum*	Temperate Migrant	x	x
Carolina Wren	*Thryothorus*	*ludovicianus*	Resident	x	x
House Wren	*Troglodytes*	*aedon*	Temperate Migrant	x	x
Winter Wren	*Troglodytes*	*troglodytes*	Temperate Migrant	x	x
Marsh Wren	*Cistothorus*	*palustris*	Temperate Migrant		x

Appendix 2 (continued). List of species detected in 2003 and 2004 fall migration studies with common name, scientific name, migratory status, and year detected.

Common Name	Genus	Species	Migratory Status	2003	2004
Brown Creeper	*Certhia*	*americana*	Temperate Migrant	x	x
White-breasted Nuthatch	*Sitta*	*carolinensis*	Temperate Migrant	x	x
Red-breasted Nuthatch	*Sitta*	*canadensis*	Temperate Migrant	x	
Brown-headed Nuthatch	*Sitta*	*pusilla*	Resident	x	x
Tufted Titmouse	*Baeolophus*	*bicolor*	Resident	x	x
Carolina Chickadee	*Poecile*	*carolinensis*	Resident	x	x
Golden-crowned Kinglet	*Regulus*	*satrapa*	Temperate Migrant	x	x
Ruby-crowned Kinglet	*Regulus*	*calendula*	Temperate Migrant	x	x
Blue-gray Gnatcatcher	*Polioptila*	*caerulea*	Neotropical Migrant	x	x
Wood Thrush	*Hylocichla*	*mustelina*	Neotropical Migrant	x	x
Veery	*Catharus*	*fuscescens*	Neotropical Migrant	x	x
Gray-cheeked Thrush	*Catharus*	*minimus*	Neotropical Migrant	x	x
Swainson's Thrush	*Catharus*	*ustulatus*	Neotropical Migrant	x	x
Hermit Thrush	*Catharus*	*guttatus*	Temperate Migrant	x	x
American Robin	*Turdus*	*migratorius*	Temperate Migrant	x	x
Eastern Bluebird	*Sialia*	*sialis*	Temperate Migrant	x	x

Appendix 3. List of all species detected per survey round in 2003. Surveys began on 8 September 2003 and ended on 23 October 2003, with each survey round representing six days.

Common name	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Totals
Wood Duck	0	0	1	0	0	0	0	0	1
Great Blue Heron	1	0	0	0	0	0	0	0	1
Green Heron	1	1	0	0	0	0	0	0	2
American Woodcock	0	0	0	0	0	2	0	0	2
Northern Bobwhite	0	0	0	0	0	0	0	1	1
Wild Turkey	0	0	0	1	0	0	1	0	2
Mourning Dove	4	6	3	0	1	12	10	0	36
Turkey Vulture	0	0	1	0	0	0	0	0	1
Sharp-shinned Hawk	1	1	2	0	2	3	4	0	13
Cooper's Hawk	2	1	0	0	0	3	3	0	9
Red-tailed Hawk	1	0	0	0	1	2	0	0	4
Broad-winged Hawk	0	0	1	0	0	0	0	0	1
Bald Eagle	0	0	1	0	0	0	0	0	1
Merlin	0	0	0	0	0	2	0	0	2
American Kestrel	0	0	1	0	0	0	0	0	1
Great Horned Owl	1	1	2	0	1	0	0	0	5
Yellow-billed Cuckoo	9	2	6	3	2	2	0	0	24
Black-billed Cuckoo	0	0	0	0	0	1	0	0	1
Belted Kingfisher	1	0	0	0	0	0	0	0	1
Hairy Woodpecker	6	5	5	7	9	4	2	3	41
Downy Woodpecker	13	11	14	11	14	13	21	23	120
Yellow-bellied Sapsucker	0	0	0	0	10	12	11	3	36
Pileated Woodpecker	1	3	5	4	6	0	4	2	25
Red-headed Woodpecker	3	0	1	0	1	1	5	2	13
Red-bellied Woodpecker	18	13	24	28	31	49	60	36	259
Yellow-shafted Flicker	18	5	45	54	102	175	32	31	462
Chuck-will's-widow	0	0	0	2	0	0	0	0	2
Whip-poor-will	2	0	0	0	0	0	0	0	2
Ruby-throated Hummingbird	1	0	0	0	0	0	0	0	1
Eastern Kingbird	2	0	0	1	0	0	0	0	3
Great Crested Flycatcher	20	3	1	2	0	0	0	0	26
Eastern Phoebe	0	0	0	2	13	3	5	7	30
Eastern Wood-Pewee	3	1	1	0	5	1	0	1	12
Yellow-bellied Flycatcher	3	0	0	0	0	0	0	0	3

Appendix 3 (continued). List of all species detected per survey round in 2003. Surveys began on 8 September 2003 and ended on 23 October 2003, with each survey round representing six days.

Common name	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Totals
Acadian Flycatcher	2	0	2	0	0	0	0	0	4
Traill's Flycatcher	0	0	0	0	2	0	0	0	2
Blue Jay	12	15	23	14	29	22	18	10	143
American Crow	16	2	12	35	3	19	44	5	136
Fish Crow	0	1	0	2	0	12	0	0	15
Orchard Oriole	1	0	0	0	0	0	0	0	1
Baltimore Oriole	10	4	0	3	0	1	0	0	18
Common Grackle	64	0	0	148	0	262	0	6	480
American Goldfinch	6	0	0	0	0	2	0	0	8
White-throated Sparrow	0	0	0	0	0	8	38	62	108
Chipping Sparrow	1	0	0	0	2	0	2	0	5
Field Sparrow	0	0	0	0	0	0	0	2	2
Slate-colored Junco	0	0	0	0	0	0	0	8	8
Song Sparrow	0	0	0	0	0	0	2	1	3
Swamp Sparrow	2	0	0	0	1	11	13	16	43
Eastern Towhee	0	0	0	0	0	0	0	3	3
Northern Cardinal	185	98	113	99	116	137	65	76	889
Rose-breasted Grosbeak	1	2	1	10	1	5	1	2	23
Blue Grosbeak	1	0	0	0	0	2	0	0	3
Indigo Bunting	1	0	3	1	8	1	3	0	17
Scarlet Tanager	5	3	7	0	5	1	0	1	22
Summer Tanager	6	11	0	0	0	0	1	0	18
Cedar Waxwing	0	0	0	35	13	0	1	3	52
Red-eyed Vireo	17	14	27	14	44	24	11	1	152
Philadelphia Vireo	0	0	0	0	2	2	0	0	4
Warbling Vireo	0	0	1	0	0	0	0	0	1
Yellow-throated Vireo	1	1	1	0	0	0	2	1	6
White-eyed Vireo	8	0	1	1	1	0	0	0	11
Black-and-White Warbler	111	36	19	16	7	14	4	0	207
Prothonotary Warbler	2	0	0	0	0	0	0	0	2
Worm-eating Warbler	7	4	0	0	0	1	0	0	12
Blue-winged Warbler	2	0	0	0	0	0	0	0	2
Nashville Warbler	0	0	1	3	0	0	0	0	4
Orange-crowned Warbler	0	0	0	0	0	1	0	0	1

Appendix 3 (continued). List of all species detected per survey round in 2003. Surveys began on 8 September 2003 and ended on 23 October 2003, with each survey round representing six days.

Common name	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Totals
Tennessee Warbler	2	0	3	0	3	0	0	0	8
Northern Parula	12	6	4	28	21	26	1	2	100
Cape May Warbler	0	0	1	2	0	0	2	0	5
Yellow Warbler	3	0	0	0	0	0	0	0	3
Black-throated Blue Warbler	52	26	11	23	11	36	17	11	187
Myrtle Warbler	0	0	0	6	25	358	609	807	1805
Magnolia Warbler	6	12	3	9	3	2	0	2	37
Cerulean Warbler	1	0	0	0	0	0	0	0	1
Chestnut-sided Warbler	8	1	0	0	0	0	0	0	9
Bay-breasted Warbler	1	0	1	1	1	0	1	1	6
Blackpoll Warbler	0	0	1	2	2	1	0	1	7
Black-throated Green Warbler	2	1	2	7	8	18	1	1	40
Pine Warbler	21	8	7	4	6	14	1	7	68
Western Palm Warbler	4	2	25	42	8	48	21	9	159
Prairie Warbler	8	3	0	4	1	1	0	0	17
Ovenbird	44	4	7	3	6	6	0	2	72
Northern Waterthrush	4	2	2	0	1	0	0	0	9
Connecticut Warbler	0	0	0	1	0	0	0	0	1
Common Yellowthroat	34	17	24	29	14	22	13	3	156
Yellow-breasted Chat	0	0	0	0	0	2	0	0	2
Hooded Warbler	0	1	0	0	2	0	0	0	3
Wilson's Warbler	0	0	0	0	1	0	0	0	1
American Redstart	141	54	45	38	65	31	5	0	379
Northern Mockingbird	1	1	2	1	1	0	0	2	8
Gray Catbird	2	3	18	44	117	90	24	23	321
Brown Thrasher	0	0	8	1	11	9	1	2	32
Carolina Wren	173	109	108	93	85	87	76	69	800
House Wren	13	1	3	1	6	0	5	0	29
Winter Wren	0	0	0	1	1	3	3	11	19
Brown Creeper	1	1	0	0	3	0	13	13	31
White-breasted Nuthatch	0	0	0	0	0	0	1	4	5
Red-breasted Nuthatch	0	0	0	0	2	2	10	3	17
Brown-headed Nuthatch	2	0	8	3	20	3	9	0	45
Tufted Titmouse	33	13	20	17	8	13	48	26	178

Appendix 3 (continued). List of all species detected per survey round in 2003. Surveys began on 8 September 2003 and ended on 23 October 2003, with each survey round representing six days.

Common name	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Totals
Carolina Chickadee	180	70	92	77	72	83	88	80	742
Golden-crowned Kinglet	0	0	0	0	0	0	172	218	390
Ruby-crowned Kinglet	0	1	3	0	2	1	67	128	202
Blue-gray Gnatcatcher	23	0	7	1	7	0	6	0	44
Wood Thrush	0	0	1	0	3	4	2	1	11
Veery	21	4	5	2	10	1	0	1	44
Gray-cheeked Thrush	0	0	0	4	5	7	2	1	19
Swainson's Thrush	2	1	2	4	9	7	8	10	43
Hermit Thrush	0	0	0	3	0	0	8	11	22
American Robin	13	7	15	17	8	65	2	19	146
Eastern Bluebird	0	0	1	0	0	1	0	0	2
Unidentified hawk	0	0	0	0	0	0	2	0	2
Unidentified flycatcher	4	3	1	0	5	1	2	2	18
Unidentified sparrow	0	0	12	0	0	0	6	1	19
Unidentified thrush	1	1	0	2	0	5	5	6	20
Unidentified vireo	2	1	0	0	0	0	10	0	13
Unidentified warbler	126	42	51	90	71	186	77	77	720
Unidentified woodpecker	0	0	0	0	0	0	0	1	1
Unidentified bird	24	5	0	0	0	56	26	39	150
Totals	**1537**	**646**	**821**	**1060**	**1061**	**2005**	**1714**	**1908**	**10716**

Appendix 4. List of all species detected per survey round in 2004. Surveys began on 15 August 2004 and ended on 12 November 2004, with each survey round representing six days. A total of 15 survey rounds were completed during the 2004 fall migration study.

Common name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	Totals
Laughing Gull	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mallard	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7
American Black Duck	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3
American Green-winged Teal	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Wood Duck	3	8	1	0	0	4	0	0	5	0	3	4	0	5	10	43
Great Blue Heron	0	0	0	1	0	1	0	0	0	0	1	0	2	1	0	6
Green Heron	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
American Woodcock	0	0	1	0	0	0	0	0	1	0	0	2	7	15	7	33
Northern Bobwhite	7	2	4	1	20	2	1	0	9	0	13	0	6	13	0	78
Wild Turkey	3	1	8	1	0	0	0	0	0	0	1	0	7	1	1	23
Rock Pigeon	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Mourning Dove	4	6	5	13	5	1	12	2	20	9	8	6	23	1	7	122
Turkey Vulture	0	1	0	1	0	0	0	0	0	0	0	0	1	8	0	11
Northern Harrier	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Sharp-shinned Hawk	0	0	0	0	0	0	3	1	10	7	6	5	3	2	0	37
Cooper's Hawk	0	0	0	0	1	0	3	0	5	1	3	3	2	0	0	18
Red-tailed Hawk	2	1	1	1	1	1	0	1	1	0	3	4	0	1	1	18
Red-shouldered Hawk	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Broad-winged Hawk	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Bald Eagle	0	1	0	0	0	2	1	0	0	2	0	0	0	0	2	8
Peregrine Falcon	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Merlin	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	2
Osprey	1	2	2	0	1	0	0	0	1	0	0	0	0	0	0	7
Eastern Screech-Owl	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Great Horned Owl	1	1	0	0	0	2	0	1	1	1	1	2	2	2	1	15
Yellow-billed Cuckoo	37	26	21	10	16	7	8	0	22	2	0	1	0	0	0	150
Black-billed Cuckoo	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	2
Belted Kingfisher	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Hairy Woodpecker	4	6	5	6	3	3	3	3	6	5	4	6	1	2	3	60
Downy Woodpecker	17	14	10	21	17	6	15	6	17	10	11	7	12	8	14	185
Yellow-bellied Sapsucker	0	0	0	0	0	0	2	1	15	10	9	12	8	2	8	67
Pileated Woodpecker	0	4	4	1	2	1	5	2	3	1	1	3	3	1	1	32
Red-headed Woodpecker	0	0	0	0	0	2	2	0	3	1	0	0	0	0	0	8
Red-bellied Woodpecker	28	35	21	19	29	33	28	23	50	40	29	50	41	30	31	487

Appendix 4 (continued). List of all species detected per survey round in 2004. Surveys began on 15 August 2004 and ended on 12 November 2004, with each survey round representing six days. A total of 15 survey rounds were completed during the 2004 fall migration study.

Common name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	Totals
Yellow-shafted Flicker	11	7	5	5	6	7	106	10	92	41	58	54	33	38	21	494
Chuck-will's-widow	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Whip-poor-will	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Ruby-throated Hummingbird	6	3	3	1	3	0	4	0	0	0	0	0	0	0	0	20
Eastern Kingbird	9	6	25	2	0	0	0	0	5	0	0	0	0	0	0	47
Great Crested Flycatcher	10	21	10	5	4	6	1	1	0	1	0	0	0	0	0	59
Eastern Phoebe	1	1	2	0	0	0	0	0	10	21	21	17	7	2	5	87
Eastern Wood-Pewee	6	3	7	0	5	4	5	4	7	6	2	5	0	0	0	54
Yellow-bellied Flycatcher	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	5
Acadian Flycatcher	1	0	1	2	0	0	2	1	0	0	0	0	0	0	0	7
Traill's Flycatcher	2	2	1	2	2	0	1	0	6	4	4	0	0	0	0	24
Least Flycatcher	0	0	0	0	2	0	3	1	0	0	0	0	0	0	0	6
Blue Jay	7	9	13	9	8	11	15	63	97	27	19	24	12	2	3	319
American Crow	13	6	2	1	4	6	3	4	4	11	2	5	1	4	7	73
European Starling	5	12	0	0	0	0	0	0	0	0	0	0	17	15	4	53
Brown-headed Cowbird	0	0	0	0	0	0	0	0	0	0	0	0	0	75	0	75
Red-winged Blackbird	0	0	0	0	0	0	0	0	7	0	1	0	53	37	40	138
Orchard Oriole	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Baltimore Oriole	3	26	27	14	5	4	2	0	2	0	0	0	0	0	0	83
Rusty Blackbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
Common Grackle	25	617	2	482	76	0	94	0	0	0	18	0	0	150	165	1629
Purple Finch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
House Finch	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
American Goldfinch	2	5	0	0	0	0	0	0	2	5	0	1	0	0	22	37
Pine Siskin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
Vesper Sparrow	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	2
Savannah Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
White-crowned Sparrow	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
White-throated Sparrow	0	0	0	0	0	0	0	0	22	51	24	85	87	69	108	446
Chipping Sparrow	0	0	0	0	0	0	0	0	0	0	3	7	0	0	1	11
Field Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
Slate-colored Junco	0	0	0	0	0	0	0	0	1	1	0	2	8	5	11	28
Song Sparrow	0	0	0	0	0	0	0	0	0	1	9	19	20	16	11	76
Lincoln's Sparrow	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1

Appendix 4 (continued). List of all species detected per survey round in 2004. Surveys began on 15 August 2004 and ended on 12 November 2004, with each survey round representing six days. A total of 15 survey rounds were completed during the 2004 fall migration study.

Common name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	Totals
Swamp Sparrow	0	0	0	0	0	0	0	0	7	7	0	4	2	1	6	27
Eastern Towhee	0	0	0	0	0	0	0	0	3	7	13	40	15	6	6	90
Northern Cardinal	207	143	108	143	115	129	105	92	124	112	101	105	88	61	67	1700
Rose-breasted Grosbeak	0	0	0	0	2	0	0	0	3	0	1	0	0	0	0	6
Blue Grosbeak	1	0	2	1	0	4	0	0	0	0	0	0	0	0	0	8
Indigo Bunting	4	2	0	0	0	1	2	1	12	0	1	0	0	0	0	23
Scarlet Tanager	0	0	0	0	0	1	5	0	2	2	1	0	0	0	0	11
Summer Tanager	11	22	14	14	20	13	7	4	0	0	1	0	0	0	0	106
Cedar Waxwing	11	4	0	0	0	0	0	0	0	0	0	0	0	7	0	22
Red-eyed Vireo	20	29	23	89	75	49	45	29	58	14	7	3	1	0	0	442
Philadelphia Vireo	0	3	3	0	0	0	1	0	2	0	0	0	0	0	0	9
Yellow-throated Vireo	0	0	0	2	0	0	0	2	1	1	0	0	0	0	0	6
Blue-headed Vireo	0	0	0	0	0	0	2	0	5	2	4	3	6	4	2	28
White-eyed Vireo	3	4	1	8	7	5	2	0	1	0	2	0	0	0	0	33
Black-and-White Warbler	27	20	18	79	54	37	17	10	50	9	3	4	0	0	0	328
Prothonotary Warbler	0	2	0	0	0	0	0	0	1	2	0	0	0	0	0	5
Worm-eating Warbler	9	4	4	3	7	1	2	0	1	0	0	0	0	0	0	31
Blue-winged Warbler	3	4	1	1	0	1	0	0	2	0	0	0	0	0	0	12
Brewster's Warbler	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
Golden-winged Warbler	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Nashville Warbler	0	0	0	0	0	0	1	0	4	0	1	0	0	0	0	6
Tennessee Warbler	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2
Northern Parula	0	0	0	3	17	11	21	29	96	17	6	7	0	0	0	207
Cape May Warbler	1	0	0	0	0	0	0	1	7	3	0	0	0	0	0	12
Yellow Warbler	1	3	0	0	2	0	0	0	0	0	0	0	0	0	0	6
Black-throated Blue Warbler	0	5	4	24	36	26	32	31	94	74	58	39	9	3	0	435
Myrtle Warbler	0	0	0	0	0	0	0	0	57	225	512	409	293	151	58	1705
Magnolia Warbler	0	0	0	6	1	3	5	0	28	11	7	0	0	0	0	61
Chestnut-sided Warbler	0	1	0	2	3	3	1	2	2	2	0	0	0	0	0	16
Bay-breasted Warbler	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	4
Blackpoll Warbler	0	0	0	0	0	0	1	2	8	7	2	5	1	0	0	26
Blackburnian Warbler	1	0	1	0	0	0	0	1	2	4	0	2	0	0	0	11
Yellow-throated Warbler	2	0	0	2	0	1	0	0	0	0	0	0	0	0	0	5
Black-throated Green Warbler	1	1	0	0	3	2	6	2	15	16	3	2	0	1	1	53

Appendix 4 (continued). List of all species detected per survey round in 2004. Surveys began on 15 August 2004 and ended on 12 November 2004, with each survey round representing six days. A total of 15 survey rounds were completed during the 2004 fall migration study.

Common name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	Totals
Pine Warbler	15	23	3	17	15	25	8	8	15	7	7	14	3	1	0	161
Western Palm Warbler	0	0	0	0	0	1	0	3	34	14	5	4	5	0	1	67
Prairie Warbler	2	1	2	2	0	1	2	1	0	1	0	0	0	0	0	12
Ovenbird	5	17	10	33	39	25	14	10	8	2	0	1	0	0	0	164
Northern Waterthrush	0	0	3	2	3	1	1	3	2	0	0	0	0	0	0	15
Louisiana Waterthrush	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	3
Kentucky Warbler	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mourning Warbler	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Common Yellowthroat	2	0	0	5	7	2	10	6	17	5	3	0	0	0	0	57
Yellow-breasted Chat	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	4
Hooded Warbler	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	3
Canada Warbler	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	4
American Redstart	57	69	24	67	125	48	59	42	92	25	3	5	0	0	0	616
Northern Mockingbird	0	0	1	1	0	1	0	1	4	1	0	2	2	0	1	14
Gray Catbird	2	1	1	2	6	12	44	24	136	63	56	42	19	4	6	418
Brown Thrasher	0	0	0	0	0	0	4	4	15	10	7	6	13	4	4	67
Carolina Wren	154	139	122	110	122	110	117	83	123	94	113	109	132	85	89	1702
House Wren	1	0	0	0	0	6	4	2	8	10	7	1	3	3	0	45
Winter Wren	0	0	0	0	0	0	0	0	8	24	24	35	43	24	28	186
Marsh Wren	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Brown Creeper	0	0	0	0	0	0	0	2	7	15	10	24	34	23	21	136
White-breasted Nuthatch	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Red-breasted Nuthatch	0	0	0	0	0	0	10	8	40	39	63	53	47	41	33	334
Brown-headed Nuthatch	2	1	0	2	0	0	0	0	0	0	0	0	0	0	0	5
Tufted Titmouse	44	46	44	32	35	19	39	32	41	43	29	29	58	27	24	542
Carolina Chickadee	50	45	41	40	57	51	45	71	117	83	75	70	75	52	63	935
Golden-crowned Kinglet	0	0	0	0	0	0	0	4	7	118	193	140	249	124	51	886
Ruby-crowned Kinglet	0	0	0	0	0	0	0	0	6	109	88	94	53	46	32	428
Blue-gray Gnatcatcher	15	9	4	8	5	1	3	3	0	0	1	0	0	0	0	49
Wood Thrush	1	1	1	1	9	1	7	0	5	4	1	1	0	0	0	32
Veery	0	0	0	15	38	25	1	2	0	0	0	0	1	0	0	82
Gray-cheeked Thrush	0	0	0	0	0	0	0	0	3	6	1	1	0	1	1	13
Swainson's Thrush	0	0	0	0	1	0	1	0	9	4	4	6	12	2	0	39
Hermit Thrush	0	0	0	0	0	0	0	0	0	2	2	20	62	74	57	217

Appendix 4 (continued). List of all species detected per survey round in 2004. Surveys began on 15 August 2004 and ended on 12 November 2004, with each survey round representing six days. A total of 15 survey rounds were completed during the 2004 fall migration study.

Common name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	Totals
American Robin	27	10	44	24	3	9	9	0	1	14	8	24	201	533	108	1015
Eastern Bluebird	0	0	0	0	3	3	0	0	0	0	0	0	0	2	0	8
Unidentified hawk	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2
Unidentified kinglet	0	0	0	0	0	0	0	0	0	5	13	1	3	1	1	24
Unidentified duck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Unidentified flycatcher	1	1	0	0	2	0	2	0	1	0	0	0	0	0	0	7
Unidentified sparrow	0	0	0	0	0	0	0	0	0	1	0	0	6	0	0	7
Unidentified thrush	0	0	0	0	0	0	0	0	0	1	0	0	1	5	1	8
Unidentified vireo	0	1	2	0	1	1	0	1	1	0	0	0	0	0	0	7
Unidentified warbler	21	53	14	44	64	36	43	37	66	46	15	21	5	2	0	467
Totals	**914**	**1496**	**687**	**1386**	**1099**	**780**	**1006**	**686**	**1791**	**1533**	**1719**	**1665**	**1814**	**1815**	**1182**	**19453**

APPENDIX B: USGS Field Surveys of Migrating Birds on Stopover in Lower Delmarva

During Fall 2004, USGS biologists conducted two field efforts to 'ground-truth' the NPOL radar sampling and to examine migrant associations with habitat at stopover sites. First, a capture-mark-recapture/re-sight study of migrating birds was conducted at Fisherman Island National Wildlife Refuge, to collect data to estimate on-the-ground densities of migrants and the number of birds departing each night, in order to 'calibrate' NPOL radar estimates of migrant exodus. Second, counts of birds were conducted in successional habitats on the Eastern Shore of Virginia National Wildlife Refuge. These counts complemented those done in forest patches in Lower Delmarva by other project participants, providing information on the relative use of these habitats by migrants, and additional ground-truthing of radar results.

Fisherman Island Banding Study

On 26 days between 21 August and 9 October, birds were captured in mist nets erected in the forest (*Prunus serotina-Sassafras albidum*) patch on Fisherman Island. Birds were identified, sexed by plumage characteristics, aged by skull pneumatization or other characteristics, and banded with bands from the USGS Bird Banding Laboratory. Birds of selected migrant species also were marked with a temporary band tag made of colored adhesive tape marked with symbols, allowing identification of individuals by sight. During the banding session (morning or afternoon, whenever an experienced observer was available), and on days between sessions, surveys were conducted throughout the area sampled by mist-nets, to search for color-marked birds and to obtain information on the number of birds that are unmarked. These surveys used playback of taped chickadee calls and human "spishes" & squeaks to lure birds in for observation; this tape was developed for use in a multi-State survey of the distribution of fall migrants near the mid Atlantic coast, conducted in the early 1990s (Mabey et al. 1993).

In total, 1098 birds of 64 species were banded (Table 1), and an additional 83 birds were captured and released unbanded. The number of birds captured varied considerably among days, ranging from < 10 to > 150, with more than 120 captured on each of three days (11-12 September, 1 October). Seventy-five birds were re-captured one or more time, and > 15 were re-sighted. However, these data were insufficient to estimate the parameters of interest (migrant density and exodus). Two issues limited the number of birds recaptured or re-sighted: insufficient field assistance, and the short duration of stopover times for most birds; it appeared that if weather conditions were favorable for migratory flight, birds often left the island within 24 hrs to resume their migration. The capture data can, however, contribute to correlations of field data with NPOL radar data, when they become available.

Counts in Successional Habitats on the Eastern Shore National Wildlife Refuge

On 12 days between 1 September and 13 October, counts of birds were conducted at points spaced at 250-m intervals across the scrub-successional habitats on the Eastern Shore National Wildlife Refuge. On each morning, 11 to 14 counts were conducted, at a random sample of points selected from among the 65 possible points. On each count, the stationary observer looked and listened for birds for 5 minutes, after which the tape of chickadee calls and human “spishes” & squeaks was broadcast to attract birds that may not have already been detected. At each point where birds were counted, vegetation characteristics were sampled within a 15-m radius circle, centered at the point. At 11 stations along each of 2 transects (oriented N-S and E-W) across the circle (22 total stations), the species or life form (e.g., grass) of live vegetation that intersected a 3-m pole were recorded in 7 height intervals: 0-0.5 m, 0.5-1 m, 1-1.5 m, 1.5-2 m, 2-2.5 m, 2.5-3 m, and > 3 m. In addition, any trees within the circle were identified and measured at breast height.

Across the season, 58 points were sampled on from 1 to 5 mornings, with 158 counts completed in total. Sixty-eight species were detected, ranging from 0 to 13 per count. The vegetation data are being summarized to describe both the vegetation structure and the relative abundance of plant species at the points. Migrant species richness and abundance is being estimated from the count data, to associate with vegetation characteristics and with NPOL radar estimates of migrant emergence from these habitats. A more detailed summary of this work and results of analyses will be included along with analyses of other components of this project, in an addendum to this report to be submitted in July-August 2007.

Table 1. Birds banded on Fisherman Island NWR, VA, Fall 2004.

Common Name	**Latin Name**	**Number banded**
Sharp-shinned Hawk	Accipiter striatus	6
Cooper's Hawk	Accipiter cooperii	1
Black-billed Cuckoo	Coccyzus erythropthalmus	2
Yellow-billed Cuckoo	Coccyzus americanus	7
Red-bellied Woodpecker	Melanerpes carolinus	4
Downy Woodpecker	Picoides pubescens	1
Eastern Wood-Pewee	Contopus virens	1
Yellow-bellied Flycatcher	Empidonax flaviventris	3
Traill’s Flycatcher (Alder/Willow)	Empidonax spp.	9
Least Flycatcher	Empidonax minimus	1
Eastern Phoebe	Sayornis phoebe	10
Eastern Kingbird	Tyrannus tyrannus	19
Warbling Vireo	Vireo gilvus	1
Philadelphia Vireo	Vireo philadelphicus	1
Red-eyed Vireo	Vireo olivaceus	129
Blue Jay	Cyanocitta cristata	70
Carolina Chickadee	Poecile carolinensis	1
Brown Creeper	Certhia americana	9
Carolina Wren	Thryothorus ludovicianus	31
House Wren	Troglodytes aedon	7
Winter Wren	Troglodytes troglodytes	1

Common Name	**Latin Name**	**Number banded**
Golden-crowned Kinglet	Regulus satrapa	1
Ruby-crowned Kinglet	Regulus calendula	1
Veery	Catharus fuscescens	39
Gray-cheeked Thrush	Catharus minimus	1
Swainson's Thrush	Catharus ustulatus	11
Wood Thrush	Hylocichla mustelina	1
Gray Catbird	Dumetella carolinensis	34
Northern Mockingbird	Mimus polyglottos	1
Brown Thrasher	Toxostoma rufum	4
Blue-winged Warbler	Vermivora pinus	2
Tennessee Warbler	Vermivora peregrina	1
Nashville Warbler	Vermivora ruficapilla	1
Northern Parula	Parula americana	28
Yellow Warbler	Dendroica petechia	2
Chestnut-sided Warbler	Dendroica pensylvanica	2
Magnolia Warbler	Dendroica magnolia	9
Black-throated Blue Warbler	Dendroica caerulescens	110
Yellow-rumped Warbler	Dendroica coronata	13
Black-throated Green Warbler	Dendroica virens	1
Prairie Warbler	Dendroica discolor	13
Palm Warbler	Dendroica palmarum	1
Blackpoll Warbler	Dendroica striata	2
Black-and-white Warbler	Mniotilta varia	45
American Redstart	Setophaga ruticilla	92
Prothonotary Warbler	Protonotaria citrea	2
Worm-eating Warbler	Helmitheros vermivorus	6
Ovenbird	Seiurus aurocapillus	25
Northern Waterthrush	Seiurus noveboracensis	89
Louisiana Waterthrush	Seiurus motacilla	1
Kentucky Warbler	Oporornis formosus	1
Common Yellowthroat	Geothlypis trichas	94
Hooded Warbler	Wilsonia citrina	1
Canada Warbler	Wilsonia canadensis	3
Summer Tanager	Piranga rubra	2
Scarlet Tanager	Piranga olivacea	1
Seaside Sparrow	Ammodramus maritimus	1
White-throated Sparrow	Zonotrichia albicollis	1
Dark-eyed Junco	Junco hyemalis	2
Northern Cardinal	Cardinalis cardinalis	29
Rose-breasted Grosbeak	Pheucticus ludovicianus	1
Blue Grosbeak	Guiraca caerulea	1
Indigo Bunting	Passerina cyanea	4
Baltimore Oriole	Icterus galbula	4

APPENDIX C: Report of Development of Software to Convert NPOL and SPANDAR Data to a GIS-Compatible Format

NPOL AND SPANDAR to GIS Programming
Final Report
January 2006

Submitted to:
Barry Truitt, Virginia Coast Reserve, The Nature Conservancy
P. O. Box , Nassawadox, VA

Prepared by:
Sarah E. Mabey, Ph.D., Department of Zoology, North Carolina State University
Campus Box 7617, Raleigh, NC 27612

The “NPOL and SPANDAR to GIS Programming Project” has been successfully completed. Dr. Sarah Mabey managed this project under the supervision of Dr. Ted Simons (NCSU) and in collaboration with Barry Truitt (TNC). The goal of this project was to create user-friendly software that would translate radar data into a format that would be easily imported into a geographic information system (GIS). Specifically, we were tasked with developing software to process data collected from NASA’s SPANDAR radar. These data are initially processed by SIGMET’s IRIS® radar processing software and stored in a format specific to the IRIS system. This project was an extension of a sister-project to create translation software to handle data from NASA’s NPOL radar.

Dr. Mabey hired and supervised two computer programmers, Payal Chakravarty and Reza Pezeshki, to assist with the software development. Together, we have created the “Universal Format Exporter” which has undergone extensive testing has been used by Dr. Mabey to reliably transfer radar data into GIS-compatible files.

The Universal Format Exporter has features that will benefit researchers with diverse interests and needs (Fig. 1). The exporter is configured to handle files from SPANDAR and NPOL and allows the user to select the following parameters:

1) elevation tilt angle of the radar;
2) radar data variables/product moments (e.g., reflectivity, velocity);
3) distance range of coverage;
4) full scan or restricted “slice” of the scan; and
5) raster size and extent.

The program creates both shapefiles and raster coverages that can be easily imported into any GIS. The shapefiles maintain the spatial configuration of the radar “bins” (native spatial sampling) while the raster coverages produce a resampled, rasterized configuration. The shapefiles also contain data variables that will allow researchers to identify each bin location by a unique “address” and relate data for individual bins from multiple scans.

The Universal Format Exporter is currently available on CDs and must be loaded on individual computers along with free, publicly available enabling software. We intend to make the exporter and related help material available online in the near future. We would like to acknowledge the help and support of Steve Ansari (NOAA's National Climatic Data Center), David Preignitz (Cooperative Institute for Mesoscale Meteorological Studies), and John Gerlach, Lester Atkins, and Nathan Gears (National Aeronautics and Space Administration).

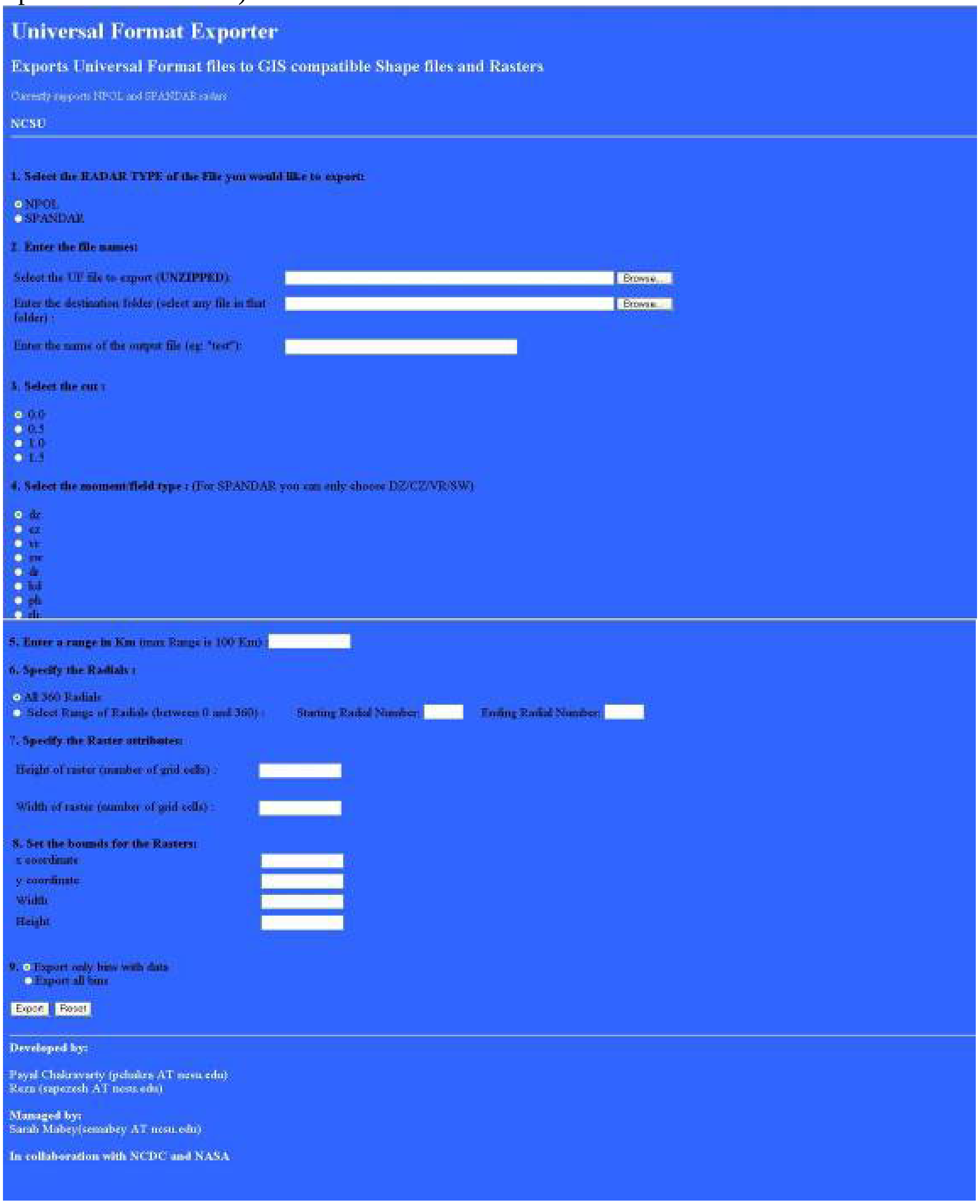


Figure 1. Graphical User Interface (GUI) for the Universal Format Exporter